As at December 7, 2024

## Schedule Overview
## Day 1: 9 December 2024 (Monday)

| Time | Event |
|---|---|
| 8:00-9:00 | Registration (Foyer [B1 floor]; Monet A&B [B1]; Opera III [B3]) |
| 9:00-9:25 | Opening Session (Picasso Room [B1]; Picasso A&B [B1]; Opera I&II [B3] [Live broadcasting])<br>**Prof. Meng Ni**<br>Associate Dean of Faculty of Construction and Environment, PolyU<br>**Prof. S.C. Wong**<br>President, Hong Kong Society for Transportation Studies (HKSTS)<br>**Dr. Wei Ma**<br>Co-Chair, the 28th HKSTS Conference |
| 9:25-9:50 | Guest of Honor Session (Host: **Prof. Anthony Chen**)<br>**Dr. Jacob Kam**<br>Chief Executive Officer, MTR Corporation Limited |
| 9:50-10:05 | Ceremony of appreciation cum Group photo |
| 10:05-10:35 | Coffee Break (Foyer [B1]; Monet A&B [B1]; Opera III [B3]) |
| 10:35-11:05 | Keynote Session<br>**The Price is Right: Towards a practical and acceptable road pricing scheme**<br>**Prof. Michiel Bliemer**<br>The University of Sydney |
| 11:05-11:35 | **Hierarchical control for large-scale multi-modal urban networks**<br>**Prof. Nikolaos Geroliminis**<br>École Polytechnique Fédérale de Lausanne (EPFL) |
| 11:35-12:05 | **Data-friendly mesoscopic network modeling: learning, prediction, and decision making**<br>**Prof. Sean Qian**<br>Carnegie Mellon University |
| 12:15-13:50 | Conference Lunch (Academy Rooms [1/F]; Café [M]) |
| 13:50-15:10 | Outstanding Student Paper Award (OSPA) cum Outstanding Dissertation Award (ODA) Presentations (Opera Room III) [B3] |
| 13:50-15:10 | **Session A1** (Picasso Room A) Urban Transit Systems Optimization<br>**Session A2** (Picasso Room B) Maritime Transport and Port Capacity<br>**Session A3** (Monet Room A) Data-Driven Traffic Flow Modeling<br>**Session A4** (Opera Room I) Multimodal Transport Systems Optimization<br>**Session A5** (Opera Room II) E-Bike Sharing System Optimization<br>**Session A6** (Opera Room III) OSPA and ODA Presentations |
| 15:10-15:40 | Coffee Break (Foyer [B1]; Picasso Room [B1]; Monet Room B [B1]; Opera III [B3]) |
| 15:10-15:40 | ***Editorial Board Meeting***: Transportmetrica A (Board Room [B1]) |
| 15:40-17:00 | **Session B1** (Picasso Room A) Electric Vehicle Grid Integration<br>**Session B2** (Picasso Room B) Traffic Safety and Accident Modeling<br>**Session B3** (Monet Room A) Adaptive Traffic Signal Control<br>**Session B4** (Opera Room I) Data-Driven Ride-Hailing Optimization<br>**Session B5** (Opera Room II) Elderly Transportation and Mobility Behavior<br>**Session B6** (Opera Room III) Air Transport Operations and Management |
| 15:40-16:40 | **Poster Session 1: Emerging and Future Mobility** (Picasso Room [B1]) |
| 15:40-16:40 | **Poster Session 2: Smart Transportation and Mobility Systems** (Monet Room B [B1]) |
| 16:30-17:00 | ***Editorial Board Meeting***: Travel Behaviour and Society (Board Room [B1]) |
| 17:30-20:00 | **Conference Banquet**<br>(ClubONE The Victoria, Tsim Sha Tsui East) |

As at December 7, 2024

**Schedule Overview**

**Day 2: 10 December 2024 (Tuesday)**

| Time | Event | | | | | |
|---|---|---|---|---|---|---|
| 8:00-9:00 | Registration (Foyer [B1 floor]; Opera III [B3]) | | | | | |
| 9:00-10:20 | **Session C1**<br>(Picasso Room A)<br>Airport Operations and Capacity Optimization | **Session C2**<br>(Picasso Room B)<br>Stochastic Traffic Flow Modeling | **Session C3**<br>(Monet Room A)<br>Automated Vehicle Behavior and Safety | **Session C4**<br>Opera Room I)<br>Public Bus System Optimization | **Session C5**<br>(Opera Room II)<br>Spatial-Temporal Traffic Modeling | **Session C6**<br>(Opera Room III)<br>AI-Driven Optimization for Transportation |
| 9:00-10:00 | **Poster Session 3: Innovative Services in Transportation** (Picasso Room [B1]) | | | | | |
| 9:00-10:00 | **Poster Session 4: Intelligent Transportation Models and Applications** (Monet Room B [B1]) | | | | | |
| 10:20-10:40 | Coffee Break (Foyer [B1]; Picasso Room [B1]; Monet Room B [B1]; Opera III [B3]) | | | | | |
| 10:40-12:00 | **Session D1**<br>(Picasso Room A)<br>Bus Service Design and Optimization | **Session D2**<br>(Picasso Room B)<br>Smart Transportation Systems Optimization | **Session D3**<br>(Monet Room A)<br>Urban Transport Accessibility and Equity | **Session D4**<br>(Opera Room I)<br>On-Demand Delivery Service Optimization | **Session D5**<br>(Opera Room II)<br>Pedestrian-Vehicle Interaction Studies | **Session D6**<br>(Opera Room III)<br>Drone Integration in Transportation |
| 10:40-11:40 | **Poster Session 5: Innovation in Transportation and Logistics** (Picasso Room [B1]) | | | | | |
| 10:40-11:40 | **Poster Session 6: Transit Management and Operations** (Monet Room B [B1]) | | | | | |
| 12:00-13:30 | Conference Lunch (Academy Rooms [1/F]; Café [M]) | | | | | |
| 13:30-14:50 | **Session E1**<br>(Picasso Room A)<br>Optimization for Connected Autonomous Vehicles | **Session E2**<br>(Picasso Room B)<br>Traffic Equilibrium and Network Optimization | **Session E3**<br>(Monet Room A)<br>Urban Mobility Infrastructure Planning | **Session E4**<br>(Opera Room I)<br>Mixed Autonomy Traffic Systems | **Session E5**<br>(Opera Room II)<br>Route Choice and Traffic Modeling | **Session E6**<br>(Opera Room III)<br>Autonomous Vehicles: Acceptance and Perception |
| 13:30-14:30 | **Poster Session 7: Transportation Modeling and Surveys** (Picasso Room [B1]) | | | | | |
| 13:30-14:30 | **Poster Session 8: Transportation, Land Use and Built Environment** (Monet Room B [B1]) | | | | | |
| 14:50-15:20 | Coffee Break (Foyer [B1]; Picasso Room [B1]; Monet Room B [B1]; Opera III [B3]) | | | | | |
| 14:50-15:20 | ***Editorial Board Meeting***: Transportmetrica B (Board Room [B1]) | | | | | |
| 15:20-16:40 | **Session F1**<br>(Picasso Room A)<br>Carbon Emissions in Traffic Management | **Session F2**<br>(Picasso Room B)<br>Rail Transit Demand and Rerouting | **Session F3**<br>(Monet Room A)<br>Demand-Responsive Transport Services | **Session F4**<br>(Opera Room I)<br>Emergency and Crisis Response Management | **Session F5**<br>(Opera Room II)<br>Urban Air Quality and Transportation | **Session F6**<br>(Opera Room III)<br>Electric Vehicle Adoption and Infrastructure |
| 16:40-17:00 | Closing Session (Picasso Room [B1]; Picasso A&B [B1]; Opera I&II [B3] [Live broadcasting])<br>**Prof. Xiaowen Fu**<br>Co-Chair, the 28th HKSTS Conference<br>**Dr. Fangni Zhang**<br>Co-Chair, the 29th HKSTS Conference | | | | | |

**Detailed Presentation**
**Day 1: 9 December 2024 (Monday)**

| Session A1: Urban Transit Systems Optimization<br>(Picasso Room A)<br>*Session Chair: Yu Zhou* | |
|---|---|
| 13:50-15:10 | **Optimising Timetable Schedules Considering Non-Traffic Hour Maintenance Window On Urban Rail Transit System (25)**<br>Yaochen Ma, Hai Wang and Hai Yang<br><br>**Optimizing Bus Depot Location And Bus Fleet Allocation For Both Regular Bus Services And Bus Bridging Services In Response To Urban Rail Transit Disruptions (57)**<br>Yunqiao Xiang, Yun Wang, Xuedong Yan, Yu Zhou and Qingwan Xue<br><br>**Scheduling Of Autonomous Modularized Trains Under Virtual Coupling Signaling (226)**<br>Maoning Chen and Hongbo Ye<br><br>**Analysis of urban rail transit resilience under differentoperation schemes: A percolation- based approach (288)**<br>Tianlei Zhu, Xin Yang, Anthony Chen, Guanwen Zeng and Jianjun Wu<br><br>**The effect of eye-level built environment on metro-bicycle integration: integrating street view images with deep learning techniques (132)**<br>Shuli Luo |

| Session A2: Maritime Transport and Port Capacity<br>(Picasso Room B)<br>*Session Chair: Kun Wang* | |
|---|---|
| 13:50-15:10 | **Extracting Maritime Traffic Route Network From Automatic Identification System Data (138)**<br>Shuo Jiang, Poong Oh and Ran Yan<br><br>**Bounds And Approximations For Port Capacity With Two-Way Channels (317)**<br>Xiaokuan Zhao and Weihua Gu<br><br>**How Does Shipping Alliance Affect Port Capacity Investment And Congestion (433)**<br>Tianyu Shang, Hao Wu, Dong Yang, Changmin Jiang and Kun Wang<br><br>**Economic Analyses On Electric Ships Adoption In Inland Water Transport And Government'S Optimal Subsidy Scheme Design (410)**<br>Ziyu Cui, Xiaowen Fu, Xiangru Wu and Kun Wang<br><br>**Transition to An Alternative-Fuel Tugboat Fleet Through Two-Stage Robust Optimization Modeling (403)**<br>Jing Wang, Shuai Jia and Yibai Zhang |

| Session A3: Data-Driven Traffic Flow Modeling<br>(Monet Room A)<br>*Session Chair: Hai Vu* | |
|---|---|
| 13:50-15:10 | **TDI: High-Resolution Trajectory Based Debris Identification Algorithm for Highway Event Management System (99)**<br>Dongyu Tian, Zhibin Li, Ruyi Feng, Shunchao Wang and Si Zheng<br><br>**A Bi-Level Calibration Method Of Microscopic Car-Following Models Based On Dynamic Traffic Flow (148)**<br>Hyeokju Nam, Jihye Byun, Dong Ngoduy and Seunghyeon Lee<br><br>**A Hybrid Neural Network For Real-Time OD Demand Calibration Under Disruptions (184)**<br>Takao Dantsuji, Dong Ngoduy, Ziyuan Pu, Seunghyeon Lee and Hai Vu<br><br>**Validation Of An Innovative Car-Following Model Using GNNs And PINNs With Multi-Modal AI On On-Board Diagnostics (256)**<br>Fumihito Furuhashi<br><br>**A Learning Network Via Multi-Stage Spatial–Temporal Feature Selection For Short-Term Traffic Flow Prediction (62)**<br>Bo Wang, Jian Zhang, Ruolin Zhao and Ke Zhang |

**Day 1: 9 December 2024 (Monday)**

| Session A4: Multimodal Transport Systems Optimization<br>(Opera Room I)<br>*Session Chair: Weihua Gu* | |
|---|---|
| 13:50-15:10 | **Adaptive routing and scheduling of network-wide rail transit services with flexible train composition (102)**<br>Shouyi Wang and Andy Chow<br><br>**A Bi-Level Optimization Model For Multimodal Transport Resource Allocation And Pricing Considering Shipper Preference (115)**<br>Yingming Yao, Xiang Zhang, Jingwen Li and Fengxin Dai<br><br>**Integrated Design Of Urban Rail Transit Fed By Feeder Bus And Shared Bike (178)**<br>Miaoqing Hu and Wai Yuen Szeto<br><br>**Optimal Trunk-Feeder Transit Network Design Under Heterogeneous Demand (316)**<br>Li Zhen and Weihua Gu<br><br>**Joint Optimization Of Seat Allocation And Pricing With Multi-Ride Season Ticket Service In The High-Speed Rail System (366)**<br>Runfa Wu, Wei Liu and Yuzhen Feng |

| Session A5: E-Bike Sharing System Optimization<br>(Opera Room II)<br>*Session Chair: Joonho Ko* | |
|---|---|
| 13:50-15:10 | **Understanding Public Bike Ticket Choice With Hourly Travel Distance Patterns: A Case Study Of Seoul Public Bike System (379)**<br>Taewoo Kim, Jonghan Park and Joonho Ko<br><br>**An E-Bike Repositioning Problem With Charging And Non-Charging Docks (23)**<br>Mingxuan Chen and Wai Yuen Szeto<br><br>**Electric Assistance Offers Greater Temperature Resilience For Active Travel Modes: Evidence From Citi Bike In New York City (440)**<br>Rong Zheng, Yuan Liang and Donggen Wang<br><br>**A Hybrid E-Bike Sharing System Design Problem Considering Multiple Types Of Facilities (147)**<br>Jiatong Song, Wai Yuen Szeto, Baicheng Li and Yi Wang<br><br>**Repositioning In Bike Sharing Systems With Broken Bikes Considering On-Site Repairs (192)**<br>Runqiu Hu and Wai Yuen Szeto |

| Session A6: OSPA and ODA Presentations<br>(Opera Room III)<br>*Session Chair: Zhuowei Wang & Mingyang Lv* | |
|---|---|
| 13:50-15:10 | **Rhythmic Control Methodology for Urban Traffic Networks under a Connected and Automated Environment**<br>Xiangdong Chen<br><br>**On The Network Equilibrium Of An Integrated Air-Ground Urban Transport System (203)**<br>Zhenwei Gong, Zhuoye Zhang and Fangni Zhang<br><br>**Obviating Explicit Matrix Manipulation for Exact Gradient Evaluation of Mathematical Programs with Equilibrium Constraints (219)**<br>Heqing Tan, Xiangdong Xu and Anthony Chen<br><br>**How Does The Large Language Model Decide To Save Pedestrians Or Passengers? Evaluation Of Ethical Dilemmas In ChatGPT-Based Decision-Making Of Autonomous Vehicles (298)**<br>Zixuan Xu, Neha Sengar and Tiantian Chen |

**Day 1: 9 December 2024 (Monday)**

| | |
|---|---|
| **Session B1: Electric Vehicle Grid Integration**<br>(Picasso Room A)<br>*Session Chair: Páraic Carroll* | |
| 15:40-17:00 | **Understanding Consumers' Non-Compensatory And Heterogeneous Preferences For Electric Vehicles (432)**<br>Jinghai Huo, Eui-Jin Kim and Prateek Bansal<br><br>**Network Equilibrium Of Battery Electric Vehicles Considering Drivers' Resting Behavior (113)**<br>Zhibin Chen, Yanling Deng, Chi Xie, Chenghe Guan and Tianlu Pan<br><br>**Flattening The Electricity Load Profile With Electric Vehicles Considering Urban Mobility (275)**<br>Jiazu Zhou, Seanglidet Yean, Tianyu Dong, Bu Sung Lee and Markus Schläpfer<br><br>**Multi-Service Electric Fleet Management For Rides, Parcel Deliveries, And Vehicle-To-Grid Services (289)**<br>Qingying He and Wei Liu<br><br>**Determining Residential Charging Station Placement By Integrating Travel Behaviours And Power Grid Capacity Constraints (340)**<br>Qihui Li, Nan Zhao and Páraic Carroll |

| | |
|---|---|
| **Session B2: Traffic Safety and Accident Modeling**<br>(Picasso Room B)<br>*Session Chair: Zhengyang Li* | |
| 15:40-17:00 | **Relating Simulated Traffic Conflicts With Traffic Accident Records – Findings From The Gojo Dori Scenario In Kyoto (48)**<br>Andreas Keler, Daijiro Maeda, Satoshi Nakao and Jan-Dirk Schmöcker<br><br>**Analysis Of Traffic Accidents Considering The Field Of View (109)**<br>Daijiro Maeda, Andreas Keler, Satoshi Nakao and Jan Dirk Schmoecker<br><br>**A Continuous Bi-Criteria Traffic Assignment Model With Safety Consideration (251)**<br>Umer Mansoor, Zhengyang Li, Guoyuan Li and Anthony Chen<br><br>**Urban Visual Clusters: Image Analysis Of Global Road Transport Fatalities (274)**<br>Zhuangyuan Fan and Becky P.Y. Loo<br><br>**How Does Subjective Perception Of Streetscape Affect Traffic Crashes? A Spatial Analysis For Integrating Safety Into Street Planning (307)**<br>Yiping Liu, Tiantian Chen, Hyungchul Chung, Kitae Jang and Pengpeng Xu |

## Session B3: Adaptive Traffic Signal Control

(Monet Room A)

*Session Chair: Wai Wong*

| | |
|---|---|
| 15:40-17:00 | **Coordinated Traffic Signal Control: Deep Reinforcement Learning With Fundamental Traffic Flow Features (118)**<br>Yifan Zhao, Lubing Li, Zhiyuan Zhou, Chak Y. Lo and Hong K. Lo<br><br>**Bayesian Traffic State Estimation For Adaptive Traffic Control (130)**<br>Zhiyuan Zhou, Lubing Li, Yifan Zhao, Ka Fai Ng and Hong K. Lo<br><br>**A Group-Based Adaptive Emergency Vehicle Priority Signal System (136)**<br>Seulbin Hong, Jihye Byun, Wai Wong and Seunghyeon Lee<br><br>**A Dynamic Programming Based Framework For Adaptive Traffic Signal Control (353)**<br>Guoyu Huang, Wei Huang and Min Huang<br><br>**Integrating A Time-Dependent Reactive Local Signal Control Policy With Queue-Based Green Light Optimal Speed Advisory (Q-GLOSA) Systems (363)**<br>Dohyeon Kim, Sooncheon Hwang, Jihye Byun, Dongmin Lee, Wai Wong and Seunghyeon Lee |

## Session B4: Data-Driven Ride-Hailing Optimization

(Opera Room I)

*Session Chair: Sisi Jian*

| | |
|---|---|
| 15:40-17:00 | **Enhancing Autonomous Mobility on Demand Systems: A Hierarchical Repositioning Approach Integrating Regional-level and Route-level Decision (164)**<br>Taijie Chen, Jingyun Liu, Zhongyou Hu, Siyuan Feng and Jintao Ke<br><br>**Graph Convolutional Networks Based Dynamic Taxi Route Recommendation (208)**<br>Youngryeong Lee, Juhyeon Kwak, Minje Choi and Seungjae Lee<br><br>**Predicting Electric Bus Power Consumption Considering Bus Route Characteristics (225)**<br>Ara Cho, Minje Choi, Sion Kim, Ilho Jeong and Seungjae Lee<br><br>**Privacy-Preserving Personalized Revenue Management Of Ride-Hailing Platform (337)**<br>Bing Song and Sisi Jian<br><br>**Modelling The Ride-Sourcing Market Under Broadcasting Matching Mode (236)**<br>Ce Wang, Jintao Ke and Kaihang Zhang |

| Session B5: Elderly Transportation and Mobility Behavior<br>(Opera Room II)<br>*Session Chair: Jiemin Xie* | |
|---|---|
| 15:40-17:00 | **Analyzing Seniors' Unrealized Leisure Needs Considering Interactive Effects Of Their Clinic Visits: A Copula-Based Approach (36)**<br>Jianbiao Wang and Tomio Miwa<br><br>**Exploring Para-Transit Choice Behaviour In Peri-Urban Areas Of Kolkata, India (46)**<br>Pritam Saha, Suchismita Nayak and Soumen Mitra<br><br>**Understanding Population Behavioral Dynamics Pattern at Urban Transportation Hub: Insights from Aggregated Mobile Phone Location Data in Kyoto, Japan (83)**<br>Alvin Noviansyah, Nobuhiro Uno, Ryoji Matsunaka and Tomoki Nishigaki<br><br>**Decoding The Spatial Effects Of Walkability On Walking Behavior Among Older Adults By Integrating Big Data And Small Data (211)**<br>Xuan He and Sylvia He<br><br>**An Integrated Optimization Model For Elderly-Friendly Public Bus Planning (13)**<br>Jiemin Xie, Fanghao Fu, Shuguang Zhan, Ming Cai and S.C. Wong |

| Session B6: Air Transport Operations and Management<br>(Opera Room III)<br>*Session Chair: Sarawut Jansuwan* | |
|---|---|
| 15:40-17:00 | **Competitive Or Complementary Relations Among Primary Airports In Japan From A Hub Performance Perspective (17)**<br>Hidenobu Matsumoto and Koji Domae<br><br>**Modeling A Risk-Averse Air Freight Forwarder'S Capacity Management Under The Post-Pandemic Demand And Flight Time Uncertainties (7)**<br>Kannapha Amaruchkul and Sarawut Jansuwan<br><br>**Resource Allocation In Air-Rail-Integrated Co-Modality Under Both Demand And Supply Uncertainties (335)**<br>Xinyi Zhu and Wei Liu<br><br>**The Impacts Of Exchange Rate Fluctuations On The International Air Passenger Transport Market: The Case Of The Chinese International Airline Market (423)**<br>Yulu He, Wenliang Ma, Keke Fan and Kun Wang<br><br>**Exploring Passenger Airline Networks Beyond Hub-And-Spoke And Point-To-Point: Opportunities And Challenges (14)**<br>Richard Klophaus |

As at December 7, 2024

**Day 2: 10 December 2024 (Tuesday)**

| | |
|---|---|
| **Session C1: Airport Operations and Capacity Optimization**<br>(Picasso Room A)<br>*Session Chair: Wei Liu* | |
| 9:00-10:20 | **Capacity Allocation Of Passenger Airlines For Air Cargo Transportation (303)**<br>Yufan Zuo and Wei Liu<br><br>**Joint Optimization Of Airport Slot Allocation And Gate Assignment: A Stochastic Integer Programming Approach (329)**<br>Xuanji Long and Wei Liu<br><br>**Airport's Optimal Decisions Considering Non-Aeronautical Business, Terminal Capacity And Different Regulatory Regimes (360)**<br>Yue Huai, Enoch Lee, Hong K. Lo and Anming Zhang<br><br>**Prediction Of Landing Time Delays With Multiple Approaching Routes To An Airport (195)**<br>Yuxin Wang, Feihong Yu, Man Fung Ho, Bo Peng, Qinhan Wen, Qiaowen Tan, Tat Shing Choi and K.Y. Michael Wong |

| | |
|---|---|
| **Session C2: Stochastic Traffic Flow Modeling**<br>(Picasso Room B)<br>*Session Chair: Zheng Liang* | |
| 9:00-10:20 | **Traffic State Distributional Estimation Based On Stochastic Physics-Informed Deep Learning (108)**<br>Ting Wang, Dong Ngoduy, Takao Dantsuji and Ye Li<br><br>**Developing And Solving A Stochastic Second-Order Traffic Flow Model Based On Multi-Element Probability Collocation Method (157)**<br>Xi Chen, S.C. Wong and Liangze Yang<br><br>**Practical Vehicle Routing In An Urban Road Network: Is Stochastic Or Time-Dependent Speed Important? (305)**<br>Stein W. Wallace, Feng Guo, Zhaoxia Guo and Michal Kaut<br><br>**Uncertainty Quantification Approaches Of Macroscopic Fundamental Diagrams In Urban Networks (257)**<br>Wenfei Ma, Yunping Huang, Xiao Jin and Renxin Zhong<br><br>**Stochastic Origin-Destination Distribution Demand Estimation from Stochastic Link Counts on Uncongested Networks (364)**<br>Jiaqi Liu, Zheng Liang and Hong K. Lo |

| Session C3: Automated Vehicle Behavior and Safety<br>(Monet Room A)<br>*Session Chair: Nang Ngai Sze* | |
|---|---|
| 9:00-10:20 | **Influences Of Individual Heterogeneity On Vehicle Damage In Two-Vehicle Lane-Changing Related Crashes: A Copula-Based Model (279)**<br>Ruifeng Gu and Nang Ngai Sze<br><br>**Transportation Safety-Based Obstacle Detour Path Planning Method For Automated Vehicles (187)**<br>Quan Yuan and Jun Li<br><br>**RTCROWD: Real-Time Crowd Simulation In The Immersive Virtual Environment (70)**<br>Haoyang Liang, Mun On Wong and Jian Sun<br><br>**A Hybrid Calibration Method Of Parameters In Microscopic Pedestrian Behavioral Models Under High-Density Walking Environment (153)**<br>Soyeon Lee, Jihye Byun, Haoyang Liang and Seunghyeon Lee<br><br>**Human-Like Interactive Lane-Changing Modeling Based On Reward-Guided Diffusive Predictor And Planner (60)**<br>Kehua Chen, Yuhao Luo, Meixin Zhu and Hai Yang |

| Session C4: Public Bus System Optimization<br>(Opera Room I)<br>*Session Chair: Yong-Hong Kuo* | |
|---|---|
| 9:00-10:20 | **Investigating The Unique Driving Patterns Of Public Light Bus In Hong Kong (69)**<br>Hing Yan Tong and Sheung Man Simon Yuen<br><br>**Strategies For Queue-Based Skip-Stop Scheme In Exclusive Median Bus Lane (119)**<br>Hee Dong Ha, Sooyeon Park and Do Gyeong Kim<br><br>**A Mixed-Integer Programming-Based Q-Learning Approach For Electric Bus Scheduling With Multiple Termini And Service Routes (170)**<br>Yimo Yan, Yonghong Kuo, Andy Chow, Yang Deng, and Qihao Wu<br><br>**Developing Bus Speed Prediction Model For Exclusive Median Bus Lanes Considering Bus Travel Demand (380)**<br>Seungbin Im, Saehim Kim, Seunghwa Jang and Joonho Ko<br><br>**Spatial-Temporal Taxi Profitability Through Data Predictive Analytics (302)**<br>Cheuk Kin Ho, Enoch Lee, Yue Huai and Hong Kam Lo |

| **Session C5: Spatial-Temporal Traffic Modeling**<br>(Opera Room II)<br>*Session Chair: Nan Zheng* | |
|---|---|
| 9:00-10:20 | **Route Choice And Traffic Equilibrium Considering A Driver Suboptimal Information Acquisition Strategy: The Deluded Rational Inattention Approach (88)**<br>Shuntaro Mega and Daisuke Fukuda<br><br>**Introducing Geographically Weighted LightGBM (GWLGBM) Models: A New Spatial Machine Learning Model (150)**<br>Fan Gao, Sylvia Y. He and Mei-Po Kwan<br><br>**From Incomplete Data To Full-Scale Traffic Prediction: An Iterative Framework With Direction-Based Traffic Data (265)**<br>Rong Cao and David Z W Wang<br><br>**TrafficGPT: Viewing, Processing And Interacting With Traffic Foundation Models (287)**<br>Siyao Zhang, Daocheng Fu, Wenzhe Liang, Zhao Zhang, Bin Yu, Pinlong Cai and Baozhen Yao<br><br>**Continuous Network-Wide Flow And Density Estimation Based On Shockwave Dynamics (262)**<br>Ahmad El Bukhari, Lina Kattan, William H. K. Lam and Wei Ma<br><br>**Mobility changes under work from home conditions: the case of Malta (430)**<br>Maria Attard |

| **Session C6: AI-Driven Optimization for Transportation**<br>(Opera Room III)<br>*Session Chair: Jinlei Zhang* | |
|---|---|
| 9:00-10:20 | **Spatial-Temporal Multi-Task Learning for Short-Term Passenger Inflow and Outflow Prediction on Holidays in Urban Rail Transit Systems (156)**<br>Hao Qiu and Jinlei Zhang<br><br>**Deep Reinforcement Learning For Solving The Integrated Airline Recovery Problem (54)**<br>Qi Wang, Xin Wen and Sai-Ho Chung<br><br>**A Reinforcement Learning Method To Solve Dynamic Truck-Drone Routing Problem (82)**<br>Wenbo Sun and Fangni Zhang<br><br>**Machine-Learning-Aided Mixed-Integer Linear Programming For Solving Transportation And Logistics Problems (98)**<br>Changlin Li and Hongbo Ye<br><br>**Optimizing Mobile Facility Planning For Disaster Response With Inequity Mitigation: A Lexicographic Distributionally Robust Optimization Approach (358)**<br>Xinyao Yu, Shoufeng Ma, Ning Zhu, Hongming Li and Jintao Ke |

## Day 2: 10 December 2024 (Tuesday)

As at December 7, 2024

| Session D1: Bus Service Design and Optimization<br>(Picasso Room A)<br>*Session Chair: Enoch Lee* | |
|---|---|
| 10:40-12:00 | **A Modified Genetic Algorithm For Solving The Bus Route Design, Express Bus Service Design And Frequency Setting Problem (64)**<br>Qiande He, Wai Yuen Szeto and Yi Wang<br><br>**Bus Network Design With The Integration Of Limited-Stop And Autonomous Bus Services (66)**<br>Mingrui Liu and Wai Yuen Szeto<br><br>**Integration Of Flexible Bus And Parcel With Ad Hoc Service Under Stochastic Demand And Service Time (232)**<br>Enoch Lee, Manzi Li, Lubing Li and Hong Lo<br><br>**A Multi-Period Asymmetric Transit Frequency Design (281)**<br>Jun Gong and Wai Yuen Szeto<br><br>**Analysing Bus Usage And Public Transport Accessibility Impacts From Long-Term Crowd-Sourced Trajectory Data (204)**<br>Theeranai Pullarp, Hyungsub Jee, Jan-Dirk Schmöcker and Kari E. Watkins |

| Session D2: Smart Transportation Systems Optimization<br>(Picasso Room B)<br>*Session Chair: Hooi Ling Khoo* | |
|---|---|
| 10:40-12:00 | **Leveraging VIIRS NTL Data To Assess The Impact Of Rail Systems On Japanese Cities (264)**<br>Heesoo Kim, Nobuhiro Uno, Ryoji Matsunaka and Tomoki Nishigaki<br><br>**Model Correction Based On Self-Feedback Adjustment Of Bulky Vehicle Over-Bridge Response Monitoring Data (434)**<br>Yucong Meng, Wanshui Han and Shujun Chen<br><br>**Optimal Dynamic Allocation Problems Of Dedicated Lanes For Pedestrians In A Heterogeneous Transport Network (97)**<br>Soyeon Lee, Jihye Byun, Dong Ngoduy and Seunghyeon Lee<br><br>**Assessment Of Potential Shared Space Street Using Analytic Hierarchy Process (AHP): A Case Study In Klang Valley, Malaysia (205)**<br>Nitya Visvanathan and Hooi Ling Khoo<br><br>**Implementing Digital Twin Solutions Into Smart City Infrastructure Management: Case Study Of NIDA Smart Campus In Thailand (385)**<br>Sarawut Jansuwan |

| Session D3: Urban Transport Accessibility and Equity<br>(Monet Room A)<br>*Session Chair: Sen Li* | |
|---|---|
| 10:40-12:00 | **Reappraisal Of Transit-Oriented Development (19)**<br>Roger Vickerman<br><br>**Understanding Urban Spatial Structure Through The Lens Of Multiple Modal Accessibility (18)**<br>Jie Huang, Xiong Meicheng and Jiaoe Wang<br><br>**Analyzing Income-Based Inequality in Transit Nodal Accessibility (89)**<br>Dong Liu, Mei-Po Kwan, Jianwei Huang, Zihan Kan, Yimeng Song and Xuefeng Li<br><br>**Are Singapore's New Towns Self-Contained? – An Examination Based On The Post-COVID Public Transport Smartcard Data (409)**<br>Yuting Hou, Jiemin Zheng, Xize Wang and Sylvia Y. He<br><br>**“Transferred Bias” Uncovers The Balance Between The Development Of Physical And Socio-Economic Environments Of Cities (428)**<br>Ce Hou, Fan Zhang, Yuhao Kang, Song Gao, Fabio Duarte, Yong Li and Sen Li |

| Session D4: On-Demand Delivery Service Optimization<br>(Opera Room I)<br>*Session Chair: Fangni Zhang* | |
|---|---|
| 10:40-12:00 | **To Grab Or Not To Grab? Revealing Determinants Of Drivers’ Willingness To Grab Orders Under The Broadcasting Mo de (31)**<br>Taijie Chen, Jian Liang, Ya Zhao and Jintao Ke<br><br>**Order Assignment For On-Demand Food Delivery Service Considering Driver Behavior (32)**<br>Jian Liang and Jintao Ke<br><br>**Crowdshipping Platform as An Intermediary: Auction-Based Mechanism Design for Order Allocation and Payment Schemes (268)**<br>Qingyang Li and Fangni Zhang<br><br>**Modeling And Optimization Of On-Demand Delivery Workforce Capacity With Endogenous Service Intensity (417)**<br>Ting Sun, Jing-Peng Wang, Peng Liu, Yipu Niu and Rui Xue<br><br>**Will Providing Return-Freight-Insurances Do More Good Than Harm To Dual-Channel E-Commerce Retailers? (76)**<br>Jiaxin Lin, Tsan-Ming Choi and Yong-Hong Kuo |

| Session D5: Pedestrian-Vehicle Interaction Studies<br>(Opera Room II)<br>*Session Chair: Tiantian Chen* | |
|---|---|
| 10:40-12:00 | **Effect Of Vehicle Velocity On Pedestrian Movement At Crosswalks: A Case Study Using Empirical Data (93)**<br>Tao Li, Zhanbo Sun, Hongliang Ding, Ruiqi Wang, Zhijian Fu and Ang Ji<br><br>**Analysis Of Pedestrian Crossing Behaviors At Unsignalized Crosswalks On Four-Lane Bidirectional Roads (188)**<br>Masahiro Yoshimura, Satoru Kobayakawa and Noriyasu Tsumita<br><br>**Understanding Pedestrian Crossing Behaviour Using Extended Theory Of Planned Behaviour: A Case Of Hyderabad, India (383)**<br>Anam Hyder and Saladi S.V. Subbarao<br><br>**Measuring Pedestrian Perception And Behavior Along An Urban Street During The Daytime And Nighttime Through The Use Of Eye-Tracking Technology (438)**<br>Carreen de Cardenas, Afrida Raida, Armanhosseini Aliabad, Eilise O'Connor, Arsalan Heydarian, Andrew Mondschein and T. Donna Chen<br><br>**Towards Understanding Worldwide Cross-cultural Differences in Implicit Driving Cues: Review, Comparative Analysis, and Research Roadmap (356)**<br>Yongqi Dong, Chang Liu, Yiyun Wang and Zhe Fu |

| Session D6: Drone Integration in Transportation<br>(Opera Room III)<br>*Session Chair: Sunghoon Jang* | |
|---|---|
| 10:40-12:00 | **Drone-Transit Cooperation For Last-Mile Delivery: A Maximal Covering Location Problem Approach (33)**<br>Suwicha Jaita, Songyot Kitthamkesorn and Sathaporn Opasanon<br><br>**Modelling The Electric Vehicle Routing Problem With Drones Under Wireless Charging Lanes Provision (134)**<br>Shishu Shen, Xiang Zhang, Ning Ma and Yan Huo<br><br>**Impact Of Perceived Service Quality Of Drone Delivery Service On Behavioral Intention To Use (293)**<br>Xinyu Chen and Sunghoon Jang<br><br>**A Branch-Price-And-Benders-Cut Approach For Optimizing The Scheduling Of Urban Subway Inspection Services Using UAVs (349)**<br>Bolong Zhou, Wenjia Zeng, Wei Liu and Hai Yang |

**Day 2: 10 December 2024 (Tuesday)**

| **Session E1: Optimization for Connected Autonomous Vehicles**<br>(Picasso Room A)<br>*Session Chair: Xin Pei* | |
|---|---|
| 13:30-14:50 | **Coordinated Distributed Trajectory Planning For Connected And Autonomous Vehicles At Expressway Bottlenecks Under Mixed Traffic Environment (78)**<br>Jingmin Lin, Chunhui Yu, Benwei Chen and Wanjing Ma<br><br>**Robust String-Stable Car-Following Control For Connected And Automated Vehicles Under Multiple-Source Information Delays (84)**<br>Yuan Zheng, Yue Fang, Shen Li, Yu Zhang, Lu Bai and Bin Ran<br><br>**Real-Time Estimation Of Residual Vehicles At A Signalized Intersection Via Partial Connected Vehicles (103)**<br>Shaocheng Jia, S.C. Wong, Wai Wong and Xin Pei<br><br>**Cooperative Lane-Changing Optimization Of Connected And Autonomous Vehicles In Freeway Merging Area (212)**<br>Xuling Liu and Xiaoning Zhang<br><br>**Communicating With Only Two Vehicles Immediately Ahead Boosts Traffic Capacity Sixfold In Connected Autonomous Vehicle (CAV) Platoons (424)**<br>Shi-Teng Zheng, Rui Jiang and Xiqun Chen |

| **Session E2: Traffic Equilibrium and Network Optimization**<br>(Picasso Room B)<br>*Session Chair: Muqing Du* | |
|---|---|
| 13:30-14:50 | **A Two-Phase Approach For Multimodal Traffic Equilibrium Assignment Based On Network Generalized Extreme Value Model (280)**<br>Muqing Du, Dongyue Cun, Guoyuan Li and Anthony Chen<br><br>**Urban Economic Analysis Incorporating A Quasi-Dynamic Traffic Assignment Model (90)**<br>Jiang Qian Ying<br><br>**Active Network Optimisation: Addressing Conflicts Between Ethics And Fairness In Transport Networks (189)**<br>Mehrdad Memarpour, Taha Hossein Rashidi, Steven Travis Waller and Ali Najmi<br><br>**Modeling The Effect Of Capacity Constraints And Queuing Toll Policies In The Bi-Modal Traffic Network Incorporating Carpooling Behavior (63)**<br>Yanqin Chen, Changxin Liao, Jia Yao, David Z. W. Wang and Anthony Chen<br><br>**Lipschitz Continuity In Interaction For Stable Equilibrium Of Multi-Agent Joint Choice Models (245)**<br>Daichi Ogawa and Eiji Hato |

| Session E3: Urban Mobility Infrastructure Planning<br>(Monet Room A)<br>*Session Chair: Can Chen* | |
|---|---|
| 13:30-14:50 | **Integrated Planning Of Vertiports And Vertipads Infrastructure For Urban Air Mobility (73)**<br>Ning Lyu and Tao Feng<br><br>**Urban Skies Reimagined: Factors Driving Advanced Aerial Mobility Acceptance in China's Greater Bay Area (104)**<br>Th Eric Chan, Tingting Li and Tim Schwanen<br><br>**Flying Path Planning With Ground Risk And Noise Mitigation For Urban Air Mobility (125)**<br>Yini Chen, Rao Fu and Shuai Jia<br><br>**A Hybrid Framework Of Traffic Simulation And Management For Large-Scale Urban Air Mobility (216)**<br>Canqiang Weng, Can Chen, Tianlu Pan and Renxin Zhong<br><br>**Comparison Of New Mobility Services Using RP-SP Mode Choice Models Considering Latent Variables And Heterogeneity (348)**<br>Hiroyuki Hasada, Anna Mizuno, Yuhan Gao, Seishu Kitamura and Ryo Kanamori |

| Session E4: Mixed Autonomy Traffic Systems<br>(Opera Room I)<br>*Session Chair: Ziyuan Gu* | |
|---|---|
| 13:30-14:50 | **Day-To-Day Traffic Control For Networks Mixed With Regular Human-Piloted And Connected Autonomous Vehicles (45)**<br>Qingnan Liang, Xin-An Li, Zhibin Chen, Tianlu Pan and Renxin Zhong<br><br>**A Modular Multi-Purpose Vehicle Routing Problem with Coupling And Decoupling: Using Modular Autonomous Vehicles For Collaborative Passenger And Freight Transport (114)**<br>Yingying Sun and Wai Yuen Szeto<br><br>**Macroscopic Modeling And Optimization Of Two-Region Mixed Autonomy Network With Park-And-Ride (196)**<br>Yifan Li, Ziyuan Gu, Nan Zheng, Wei Ma and Zhiyuan Liu<br><br>**Modelling The Social Interactions At Mixed-Flow Intersection With Multi-Agent Imitation Learning (37)**<br>Shihan Wang, Ying Ni, Jian Sun and Jie Sun<br><br>**Infrastructure-Enabled Automated Network Design For Mixed Traffic (342)**<br>Qingyun Tian, Yunhui Lin and Zhiwei Wang |

| Session E5: Route Choice and Traffic Modeling<br>(Opera Room II)<br>*Session Chair: Takamasa Iryo* | |
|---|---|
| 13:30-14:50 | **Joint Estimation Of Latent OD Matrix And 3D Route Choice Model Across Railway Station Boundaries Based On Manifold Learning (229)**<br>Takahiro Matsunaga and Eiji Hato<br><br>**Dynamics Of In-Station Time Within Metro Systems: Measurement And Determining Factors (20)**<br>Hui Wang and Becky P.Y. Loo<br><br>**A Fast Algorithm For Computing Route Choice Probabilities In Large-Scale Dynamic Road Networks (222)**<br>Kouki Matsumoto, Masaaki Ishihara and Takamasa Iryo<br><br>**Adaptive Route Planning for Scheduling Autonomous Mobile Chargers for Electric Vehicles (411)**<br>Jeong Seomun, Seunghyeon Lee and Jihye Byun |

| Session E6: Autonomous Vehicles: Acceptance and Perception<br>(Opera Room III)<br>*Session Chair: Dianchen Zhu* | |
|---|---|
| 13:30-14:50 | **Understanding Public Opinions Of Autonomous Vehicles In China: A Social Media Analytics Approach (105)**<br>Dongdong Oliver Feng and Sylvia Y. He<br><br>**The Right-Of-Way Assignment Strategy At The Intersection Approach Under Mixed Traffic: Considering The Heterogeneity Of HDV Drivers' Confidence In CAVs (291)**<br>Huan Wu, Fang Zong, Meng Zeng and Pei-Xin Shi<br><br>**Factors Affecting The Acceptance Of Autonomous Vehicles: A Case Study Of Seoul, South Korea (373)**<br>Ria Roida Minarta, Jonghan Park and Joonho Ko<br><br>**Impact Of Risk Perception And Trust In Autonomous Vehicles On Pedestrian Crossing Decision: Navigating The Social-Technological Intersection With The ICLV Model (445)**<br>Zhongxiang Feng, Ya Gao, Dianchen Zhu and Bin Zhou<br><br>**Investigating perception, critical scenarios and training gaps for autonomous driving systems – a human intervention perspective (482)**<br>Zheng Xu, Nan Zheng |

**Day 2: 10 December 2024 (Tuesday)**

| **Session F1: Carbon Emissions in Traffic Management**<br>(Picasso Room A)<br>*Session Chair: Jiangbo Wang* | |
|---|---|
| 15:20-16:40 | **Green Family Vehicle Routing Problem (79)**<br>Pin Yin Chiang and Chin Sum Shui<br><br>**Modelling Dynamic Spatial-Temporal Carbon Emission Exposure With Heterogeneous Traffic Flows (94)**<br>Yaxin Wu, Xiaowei Hu, Jiyong Liao, Yujia Wang and Yu Jiang<br><br>**Customized Commuting Bus Routing Under Carbon Emissions Regulations (239)**<br>Zhongyu Sun, Jiangbo Wang and Kai Liu<br><br>**Applications Of The Agent-Based Model To Estimate The Environmental Impacts Of Construction On The Neighbourhood (44)**<br>Xiangyi Li, Rosana W.M. Wong and Becky P.Y. Loo |

| **Session F2: Rail Transit Demand and Rerouting**<br>(Picasso Room B)<br>*Session Chair: Prateek Bansal* | |
|---|---|
| 15:20-16:40 | **Integration Study Of Individual Travel Prediction And Passenger Flow Forecasting: Based On The Individual Travel Patterns Of Rail Transit Passengers (277)**<br>Jing Wang, Jian Zhao, Kai Liu and Jiangbo Wang<br><br>**Identification, Categorization And Rationalization Of Metro Passenger Rerouting Choices Under Metro Disruptions With A Hierarchical Utility-Based Route Choice Model (421)**<br>Kejun Du, Enoch Lee, Qiru Ma and Hong Lo<br><br>**Fusing Household Travel Survey And Smart Card Data To Generate Spatiotemporally Heterogeneous Activity Schedules For Transit Riders (431)**<br>Khoa Vo, Eui-Jin Kim, Huichang Lee and Prateek Bansal<br><br>**Estimating Intercity Railway Travel Demand Of A Mega-City Region: A Hybrid Multi-Source Data-Driven And Model-Driven Approach (451)**<br>Zijian Wang, Kai Qu, Xiangdong Xu, Chao Yang, Li Guo and Jiaqi Hu<br><br>**Modelling the expected performance of urban rail transport operations for benchmarking (101)**<br>Anupriya Anupriya and Daniel Graham |

| Session F3: Demand-Responsive Transport Services<br>(Monet Room A)<br>*Session Chair: Kenan Zhang* | |
|---|---|
| 15:20-16:40 | **What Do Walking And E-Hailing Bring To Scale Economies In On-Demand Mobility? (453)**<br>Kenan Zhang, Javier Alonso-Mora and Andres Fielbaum<br><br>**Online Operations Of A Mixed-Fleet Ride-Hailing Service System Catering To Specialized Needs Of Seniors (126)**<br>Xindi Tang, Xiaozhuang Li, Fang He and Yang Liu<br><br>**Pricing Strategies In Demand-Responsive Transport Services (5)**<br>Weemeng Yeo<br><br>**Classifying Performance Level Of Demand Responsive Transport Services In Taiwan: A Context-Dependent Data Envelopment Analysis (198)**<br>Barbara T.H. Yen, Corinne Mulley, Shuo-Chen Hsieh and Yu-Wen Pai<br><br>**Consumer Engagement And The Adoption Of Emerging Sustainable Transport Options In China And Denmark (454)**<br>John Thøgersen and Ting Zhang |

| Session F4: Emergency and Crisis Response Management<br>(Opera Room I)<br>*Session Chair: Zhibin Chen* | |
|---|---|
| 15:20-16:40 | **Dynamic Reconfiguration Strategies For Managing Shelter And Road Congestion In Urban Emergency Evacuations (238)**<br>Satoki Masuda and Eiji Hato<br><br>**Robust Location For Quarantine Facilities Under Decentralized Room Assignment: A Bi-Level Mixed-Integer Programming Approach (58)**<br>Yuhao Liu, Zhibin Chen and Joseph Chow<br><br>**Causal Analysis Of The Impact Of Telework During COVID-19 On Activity Choice Behavior In Tokyo (231)**<br>Ryuhei Kurasawa, Eiji Hato and Xiao Fu<br><br>**Criticality Road Segment Identification For Enhancing Post-Event Network Efficiency Through Graph Attention Networks (425)**<br>Yitao Yao, Bin Jia and Tingting Zhao<br><br>**Ripple Effect Of Ammonia Supply Disruption On The Ammonia Bunker Supply Chain (452)**<br>Mengyao Yang and Jasmine Siu Lee Lam |

| Session F5: Urban Air Quality and Transportation<br>(Opera Room II)<br>*Session Chair: An Wang* | |
|---|---|
| 15:20-16:40 | **Did A Transformative Public Transport Investment Improve Air Quality? Elizabeth Line In London (100)**<br>Liang Ma, Kai Reis Darius Cooper, Marc E.J. Stettler and Daniel J. Graham<br><br>**Subway Expansion, Road Congestion, And Urban Air Quality (339)**<br>Xiaolong Li, Xiaowen Fu and Daqing Gong<br><br>**Air Pollution And Travel To School – Part I: A Theoretical Bi-Modal School Trip Model (393)**<br>Kim N. Dirks, Judith Y. T. Wang and Matthias Ehrgott<br><br>**Air Pollution And Travel To School – Part II: A Cloud-Based Smart App For Walking School Buses (394)**<br>Timothy J. Amsdon, Judith Y. T. Wang, Jin Liu and Edward Brown<br><br>**Assessing Zero-Emission Bus Market In Hong Kong From A Lifecycle Perspective (215)**<br>Zhuowei Wang, An Wang, Anthony Chen and Hongxing Yang |

| Session F6: Electric Vehicle Adoption and Infrastructure<br>(Opera Room III)<br>*Session Chair: Xiao Fu* | |
|---|---|
| 15:20-16:40 | **Impact Of Electric Vehicle Promotion On Carbon Emissions From Passenger Cars Under Diverse Policy Scenarios (384)**<br>Peimin Wu, Xuan Ma and Xiao Fu<br><br>**Innovations In The Electric Vehicle Industry: Insights From Two Decades Of Patent Data (35)**<br>Zhixuan Li and Becky Loo<br><br>**Public Acceptance And Adoption Of Electric Mobility Devices For Last-Mile Travel In Hong Kong (437)**<br>Jin Wang, R.C.P. Wong and W.Y. Szeto<br><br>**Optimizing Battery Swapping And Bike Repositioning Strategies For Electric Bike-Sharing Systems (28)**<br>Jia Cui and Wai Yuen Szeto<br><br>**Green Services Operations For Electric Vehicle Battery Charging And Swapping Service Modes (174)**<br>Sirui Hong and Jiuh-Biing Sheu |

**Detailed Presentation**

As at December 7, 2024

**Day 1: 9 December 2024 (Monday)**

| | |
|---|---|
| **Poster Session 1: Emerging and Future Mobility** (Picasso Room B1) | |
| 15:40-16:40 | **Evaluating the Spatial Layout of Public Charging Infrastructure for E-Taxis Using GPS Trajectory Data (194)**<br>Meng Liu and Sylvia He<br><br>**Incorporating Mobile Internet Usage Data to Explore the Impacts of Human Mobility Patterns on Shopping Malls (319)**<br>Jiping Xing, Xiaohong Jiang, Jianhua Deng, Churong Chen and Kai Zhang<br><br>**Evaluating the Safety Impact of Regional Communication Failures on Connected and Automated Vehicles (347)**<br>Haosong Wen, Weijie Yu and Wei Wang<br><br>**Optimizing EMS Responses Post-Disaster: Robust Allocation of Ambulances Considering Travel Time Uncertainties (325)**<br>Huiying Zhao, Huijun Sun, Hao Fu and Jianjun Wu<br><br>**Regulating Discriminatory Pricing Against Existing Customers in the Transportation Market Considering Supply-Demand Congestion Effects and Duopoly Competition (332)**<br>Jinshu Cai, Yanyan Ding and Sisi Jian<br><br>**Integrating Personal Rapid Transit System at Signalized Intersections: Designing, Simulation, and Implication (442)**<br>Lanhang Ye, Toshiyuki Yamamoto, Takayuki Anamoto, Kazuyuki Umiguchi and Takayuki Morikawa<br><br>**Cost-Competitiveness Analysis of Mobile Chargers in an Electric Vehicle Parking and Charging System (143)**<br>Yanling Deng, Zhibin Chen and Xi Lin<br><br>**Evaluating Traffic Performance of Dedicated Lanes for Connected and Automated Vehicles at Urban Roundabouts (246)**<br>Xu Zhang and Zhiman Xu<br><br>**Leverage Multi-Source Traffic Demand Data Fusion with Transformer Model for Urban Parking Prediction (355)**<br>Yin Huang, Yongqi Dong, Youhua Tang and Li Li<br><br>**Co-Design of Traditional and Demand-Responsive Transit Based on Existing Stops (441)**<br>Zili Tian, Jiaorong Wu, Sicheng Wang and Chi Zhao<br><br>**Unlocking the Potential of Drones in Revolutionizing Intra-City Express Services: A Cost-Efficiency Analysis (322)**<br>Xiao Chu, Shuiwang Chen, Kai Wang, Lingxiao Wu and Gangyan Xu<br><br>**An Analysis of Tourists' Willingness-to-Pay for Bundled One-Day Transport Ticket in the Central Nagoya with the Price Sensitivity Measurement (359)**<br>Gen Hayauchi, Ryo Kanamori and Takayuki Morikawa<br><br>**Enhancing On-Ramp Area Control in Heterogeneous Traffic Flow: A Dual-Module Cooperative Approach for Connected and Automated Vehicles Leveraging Reinforcement Learning (42)**<br>Wenzhang Yang, Changyin Dong, Ziqian Zhang, Xu Chen and Hao Wang |

| | |
|---|---|
| | **Optimizing Vehicle Responses in Accident Scenarios: A Reinforcement Learning Approach with V2X Communication (122)**<br>Hyunseop Sim and Shin Hyoung Park<br><br>**An End-to-End Predict-Then-Optimize Method for On-Demand Vehicle Reallocation in Mobile Sensing (158)**<br>Xinyu Wang and Wei Ma<br><br>**Efficient Model Compression for Improving Traffic Object Recognition Using Lightweight Pruning Algorithm (96)**<br>Huihuang Zhu, Ruyi Feng and Zhibin Li |

| **Poster Session 2: Smart Transportation and Mobility Systems**<br>(Monet Room B [B1]) | |
|---|---|
| 15:40-16:40 | **Enhanced Object Detection Algorithm with Prediction Box Extension (387)**<br>Sifeng Wang, Guizhen Yu, Zhangyu Wang, Simiao Gao and Pengcheng Wang<br><br>**Modular Autonomous Vehicle in Heterogeneous Traffic Flow: Modeling, Simulation, and Implication (443)**<br>Lanhang Ye and Toshiyuki Yamamoto<br><br>**Resource Allocation for Dynamic Platoon Digital Twin Networks: A Multi-Agent Deep Reinforcement Learning Method (91)**<br>Lei Wang and Hongbin Liang<br><br>**Understanding the Psychological Factors Affecting Non-Users' Adoption of Public Transportation: Case Study of Surat, India (397)**<br>Raj Prajapati, Rohit Rathod, Janak Parmar, Gaurang Joshi, and Sanjay Dave<br><br>**The Effect of Air Quality on the Distribution of Tourists Based on Mobile Phone Data (285)**<br>Hongjian Bai, Xiao Huang, Kunbo Shi and Yacan Wang<br><br>**How Do the Drivers React to Different C-V2X Environments in Dilemma Zones? A Driving Simulator Study (296)**<br>Shi Ye, Tiantian Chen, Oscar Oviedo-Trespalacios, Taeho Oh and Inhi Kim<br><br>**Battery Swapping Station Location and Charging Scheduling for the E-Bike Sharing System under Stochastic Demand (370)**<br>Yisong Chen, Zhimian Wang, Kun An and Hai Jiang<br><br>**Revealing Charging Patterns of Electric Vehicles with Intrinsic Usage Heterogeneity (72)**<br>Ruinan Wang, Zhibin Chen and Zhengtian Xu<br><br>**Generalizable Implicit Neural Representation as a Universal Spatiotemporal Traffic Data Learner (127)**<br>Tong Nie, Guoyang Qin, Wei Ma and Jian Sun |

**Day 2: 10 December 2024 (Tuesday)**

| **Poster Session 3: Innovative Services in Transportation**<br>(Picasso Room [B1]) | |
|---|---|
| 9:00-10:00 | **Ridesharing User Equilibrium Model and Its Equivalent Variational Inequality Formulation Without Monotonicity: A Decomposition-Based Approximation Approach (336)**<br>Wenxin Zhou, Xiaolei Wang, Jie Yang and Xiaoning Zhang |

**Modeling the Uncertainties from Data Imperfection and Taste Heterogeneity in Link-Based Route Choice Analysis via Bayesian Variational Inverse Reinforcement Learning (BVIRL) (449)**
Junze Yang and Xiangdong Xu

**A Multi-Context Aware Human Mobility Prediction Model Based on Motif-Preserving Travel Preference Learning (30)**
Yong Chen, Ningke Xie, Haoge Xu, Xiqun Chen and Der-Horng Lee

**Powering the Ride: A Data-driven Approach to Uncovering the Potential Charging Demand for Electric Ride-hailing Vehicles (131)**
Zhicheng Jin and Xiaotong Sun

**On the Value of Orderly Electric Vehicle Charging in Carbon Emission Reduction (247)**
Zhi Li, Zhibin Chen, Hailong Li, Chenghe Guan and Minghui Zhong

**An Integrated Lane Width Design Method Considering the Dedicated Lane for Electric Bicycles (447)**
Yuzheng Guo, Jichen Zhu, Yuqi Shi and Xiaoguang Yang

**An Auction-Based Driver Assortment Approach for Unattractive Ride-Hailing Orders Considering the Drivers' Preferences (139)**
Yitong Zhang, Qian Ge and Ke Han

**Online Optimization of Integrated Charging and Parking Services Considering Vehicle Relocation (237)**
Jie Lin and Fangni Zhang

**Design of Smart Electric Vehicle Charging Services under Demand and Renewable Energy Uncertainties: A Two-Stage Stochastic Optimization Model (331)**
Lin Yu, Yanyan Ding and Sisi Jian

**Integrating UAV Technology in Last-Mile Delivery: A Case Study of the Topical in India and Its Implications for Smart Urban Mobility (116)**
Yilin Liu

**Joint Optimization of Incentive and Routing Strategies in Crowdsourced Last-Mile Delivery (240)**
Dongze Li and Fangni Zhang

**Technological Advances in Rural Logistics: The Benefits of Electric Cable Cars (218)**
Yiqing Liang and Becky P.Y. Loo

**Coordinative Dispatching of Shared and Public Transportation under Passenger Flow Outburst (163)**
Xiaohan Wang, Xiqun Chen, Chi Xie and Taesu Cheong

**Evaluation of Novel Mobility Service Mixed Ride-Share with Shuttle Bus for a Shopping Center in Suburban Residential Area (352)**
Ippei Morita, Anna Mizuno, Hiroyuki Hasada, Seishu Kitamura and Ryo Kanamori

**GNN-Based Explainable Traffic Congestion Prediction with GNNExplainer (41)**
Yuhang Yang and Shuyang Zhang

**A New Method for Non-Destructive Diagnosis of Semi-Rigid Base Damage Condition of Asphalt Pavement (65)**
Lulu Yang, Zhang Chen, Di Zhao, Yingdong Yao and Tianxu Li

**Mechanism Design for Coordinating Vehicle-Based Mobile Sensing Tasks Within the Ride-Hailing Platform (120)**

| | |
|---|---|
| | Shenglin Liu, Qian Ge and Ke Han |



| Poster Session 4: Intelligent Transportation Models and Applications (Monet Room B [B1]) | |
|---|---|
| 9:00-10:00 | **TrTr: A Versatile Pre-Trained Large Traffic Model Based on Transformer for Capturing Trajectory Diversity in Vehicle Population (68)**<br>Ruyi Feng, Huihuang Zhu, Zhibin Li, Bowen Liu and Sze N.N.<br><br>**Large Language Model-Enhanced Reinforcement Learning for Generic Bus Holding Control Strategies (137)**<br>Jiajie Yu, Yuhong Wang and Wei Ma<br><br>**Optimal Tour Length Estimator for Vehicle Routing Problems in Real Road Networks Using Graph Neural Networks (145)**<br>Hongzheng Shi, Jiguang Wang and Jintao Ke<br><br>**Traffic Conflict Analysis with Surrogate Safety Measures by Latent Representations (234)**<br>K.I. Wong and J.S. Lin<br><br>**Injury Severity Analysis of Road Traffic Accidents in Hong Kong: A Comparative Study Before and During the COVID-19 Pandemic (309)**<br>Qiaoqiao Ren, Chak Kei Li and Min Xu<br><br>**V-RP3D: Enhancing Roadside LiDAR-based Perception through Domain Generalization from Vehicle Perspective in 3D Object Detection. (396)**<br>Chin Long Ng, Yafei Wang, Bowen Wang, Zexing Li and Ruoyao Li<br><br>**Representation-Enhanced Behavior Planning Using Vector Quantized Encoding for Autonomous Driving (416)**<br>Jingda Wu, Chao Huang and Hailong Huang<br><br>**Automated Energy-Efficient Adjustment of Adaptive Cruise Control Speed Setting Using Near Real-Time Downstream Vehicle Trajectory Data (456)**<br>J. CARPIO<br><br>**Unraveling Preference Heterogeneity in Metro Route Choice Using Mobile Phone Data (350)**<br>Xiaolei Liu, Zhengyu Duan, Qing Yu and Mengyi Wang |

| Poster Session 5: Innovation in Transportation and Logistics (Picasso Room [B1]) | |
|---|---|
| 10:40-11:40 | **Identification of Hazardous Sections in Small-Vehicle-Only Underground Roads Using 3D Simulation: A Case Study of the Seobu Underground Expressway (367)**<br>Hyung Joon Bang, Youngkyun Kang, Dohoon Kim and Taekyoung Kim<br><br>**Traffic Origin–Destination Matrices Prediction with Consideration of Travel Frequency (15)**<br>Shulin Huang, Cheng Zhang and Jing Zhao<br><br>**A City-Scale Traffic Dataset for Comprehensive Urban Research in 10 UK Cities (140)**<br>Xiangcheng Li, Xiaotong Xu and Wei Ma<br><br>**Distance-Informed Neural Eikonal Solver for Reactive Dynamic User-Equilibrium of Macroscopic Continuum Traffic Flow Model (27)**<br>Yun Ye, Haoyang Liang, Jian Sun and Xiqun Chen<br><br>**Integrating Spatial Insights with Machine Learning to Estimate Annual Average Daily Traffic by Vehicle Type on Local Roads (182)** |

Rami Al-Shukairi, Liang Ma, Marc E.J. Stettler and Daniel J. Graham

**Evaluation Method for Voids Beneath Airfield Rigid Pavement Slabs Based on Strain Sensing (446)**
Zerui Zhao, Jianming Ling, Fan Yang, Jiake Zhang and Zhongxu Guo

**Analysis of Reward Programs for Liner Shipping Services (92)**
Tianfang Ma, Xuecheng Tian, Yan Liu and Shuaian Wang

**Two-Stage Drone Delivery Network Design with Uncertain Demand (121)**
Wenjia Zeng, Ruiwei Jiang, Hai Yang and Hai Wang

**A Study on Travel Behavior Analysis of Container Semi-Trailer Truck by Travel Type (124)**
Jinwon Jang, Sangkyu Lee and Dongjoo Park

**Blockchain-Based Cross-Border Logistics Platform Operations: A Game-Theoretic Analysis (146)**
Qilong Li and Haohan Xiao

**Unveiling Heterogeneity of Urban Goods Vehicles' Route Choice Behavior: Analysis Using GPS Data from the Tokyo Metropolitan Area (209)**
Yumi Hazenoki, Takanori Sakai, Hideki Oka and Tetsuro Hyodo

**Candidate Forward Warehouses Locations for the Last Mile Fresh Product Delivery (330)**
Rongjie Sun, Zuoning Jia, Kun An and Shadi Sharif Azadeh

**Integrating Excess Demand Data into Transportation Planning for South Korea's Rail Network (81)**
Heejo Kim, Hyungkeun Son and Dongjoo Park

**Risky Behavior Analysis for Cross-Border Drivers: A Logit Model and Qualitative Comparative Analysis of Odds of Fault and Injury Vulnerability in Guangdong, Hong Kong, and Macau (39)**
Guangnan Zhang, Qiaoting Zhong, Ying Tan and Qingxuan Yang

**Performance Evaluation Scope: Comparing Route-Based and Region-Based Evaluation in Public Transport (207)**
Fu Chiang, Chia-Jung Yeh, Xin Wang and Yu-Cheng Ting

**Transportation Modeling to Understand Mobility Needs in Rural Areas (55)**
Lutz Gaspers, Dennis Dreher, Leo Casey and Hannah Walter

**A Flexible Multi-Set Strategy for Cross-Line Routing Operating in Urban Rail Transit to Address High-Density, Short-Term Transfer Passenger Demand (21)**
Xin Guo, Zhenbin Zhang, Jin Zhou and Huijun Sun

## Poster Session 6: Transit Management and Operations

(Monet Room B [B1])

10:40-11:40

**A Predict-Decompose Algorithm for On-Demand Dynamic Ride-Pooling Problem Considering Order Cancellations (29)**
Jiguang Wang, Xinglu Liu and Jintao Ke

**A Bi-Level Reinforcement Learning Method for Customized Bus Planning Considering Dynamic Passenger Interactions (75)**
Zinuo Cao, Wanshan Li, Sujun Sun and Xin Xia

| | |
|---|---|
| | **Personalized Fair Matching in Peer-to-Peer Ridesharing Platforms Under Broadcasting Mode: A LLM-Driven Driver Approach (77)**<br>Shen Zijian, Taijie Chen, Jiguang Wang and Jintao Ke<br><br>**Optimization of Multi-Discount Fare Setting for Public Transit Considering Travel Frequency Distribution (111)**<br>Runda Chen, Sujun Sun and Fangtong Liu<br><br>**Exploring the Dynamic Evolution of Passenger Flow Fluctuations in Urban Complex Metro Networks (135)**<br>Yangyang Meng, Xiaofei Zhao and Wei Ma<br><br>**Optimal Operating Strategy of the Ride-Sourcing Company Under Market Aggregation (144)**<br>Xin Zhang and Gege Jiang<br><br>**Analysis of Cascading Failure in Urban Metro Networks: A Dynamic Perspective Incorporating Changes in Travel Decisions (250)**<br>Huiying Lei, Xuedong Hua, Weijie Yu, Yongtao Zheng and Wei Wang<br><br>**Joint Optimization of Scheduling and Passenger Matching for Multi-Route Conventional and Flexible Integrated Bus Services (333)**<br>Xinyan Zhang, Jia Gao, Yushi Pan and Kun An<br><br>**Optimal Subsidy Scheme Design for Construction and Demolition Waste Recycling (129)**<br>Lei Yu, Qian Ge and Ke Han |

| **Poster Session 7: Transportation Modeling and Surveys**<br>(Picasso Room [B1]) | |
|---|---|
| 13:30-14:30 | **Integrated Optimization of Railway Capacity Allocation and Pricing for High-Speed Rail Express Delivery Considering Uncertain Demand and Uncertain Capacity (365)**<br>Mengrong Yan, Guangming Xu and Linhuan Zhong<br><br>**The Impact of Pandemic Wave on Work Patterns and Commuting Frequency: A Retrospective Survey Analysis of Convid-19 Data in Shanghai (354)**<br>Meiping Yun, Yijia Dong and Yue Ma<br><br>**A Planning Model for Multi-Terminal Electric Bus System (413)**<br>Xiaokuan Zhao, Jie Ma and Weihua Gu<br><br>**Comprehensive Optimization for High-Speed Railway Passenger Train Line Planning and Ticket Allocation Under Random Demand (304)**<br>Guangming Xu, Ziqi Zhu, Linhuan Zhong and Yini Xiao<br><br>**Two-Stage Stochastic Optimization of Seat Allocation and Flexible Composition for High-Speed Railway Considering the Uncertainty of Epidemic (344)**<br>Can Li, Guangming Xu and Xinyi Liu<br><br>**A Passenger Behavior Simulation Model for Metro Transfer Corridor Considering Commercial Attraction (40)**<br>Liangji Tang, Fangsheng Wang and Ling Hong<br><br>**Recreational Marijuana Legalisation: Has Traffic Safety Worsened in the US? (56)**<br>Anupriya Anupriya and Daniel Graham<br><br>**Estimating Source of Traffic Congestion from Vehicle Trajectory Data Using Hierarchical Bayesian Model (67)** |

Kazuma Hayashi and Toru Seo

**Stochastic Lighthill-Whitham-Richards Traffic-Flow Model for Nonlinear Speed-Density Relationship (87)**
Tianxiang Fan, S.C. Wong, Zhiwen Zhang and Jie Du

**Hysteresis Phenomenon in Traffic Safety Analysis (258)**
Peilin Zhao, Yiik Diew Wong and Feng Zhu

**Optimising Last-Mile Delivery Network: Locker-Drone Logistics System Design Under Uncertain Demand (455)**
Yunxiang SHU, Zhongyi JIN, Chenliang ZHANG, Kam K.H. NG

**Multi-Period Bicycle Network Design Using Genetic Algorithm (26)**
Chin Sum Shui and Yuk Chau

**Considering Path Order and Perceptual Correlations in a Tolled Network with Ordered GEV Model (230)**
Yu Gu and Anthony Chen

**Constructing a Public Transport Simulation by Fusing Open Source Data into SUMO with Kyoto Case Study (49)**
Andreas Keler, Tomoki Nishigaki and Jan-Dirk Schmöcker

**Improving Transportation Network Redundancy by Integrating Link Addition and Link Retrofitting (213)**
Kai Qu, Xiangdong Xu and Anthony Chen

**Bus Local Route or Coverage Route? Bus Route Choice Behavior with Latent Class Model (254)**
Barbara T.H. Yen, Chia-Jung Yeh, Yu-Chiun Chiou and Jin-Yuan Wang

**Promoting Gender-Inclusive Transport and Enhancing Mobility of Women (436)**
Nazam Ali and R.C.P. Wong

**Poster Session 8: Transportation, Land Use and Built Environment**

(Monet Room B [B1])

13:30-14:30

**What contributes to individual’s ‘15-minute city’ travel behavior? An investigation of a national travel survey in the Netherlands (51)**
Tanhua Jin, Eric Koomen and Zheng Liang

**Examining elderly activity in singapore: the role of perceived and physical accessibility (362)**
Wei Zhou and Ghim Ping Ong

**A copula-based approach for jointly modeling injury severities of drivers at vehicle level in truck-involved crashes (382)**
Penglin Song and N.N. Sze

**Assessing the impact of a circle line on the resilience of the shanghai metro network (450)**
Shicheng Zhao and Xiangdong Xu

**Correlation between the built environment and dockless bike-sharing trips connecting to urban metro stations (169)**
Jiaomin Wei, Zihan Kan, Mei-Po Kwan, Zhuo Liu, Yanyan Chen and Yang Wang

**Exploring the Crash Effects of Roadway Attributes and Elements on Roadway Segments in an Urban Mixed Traffic Environment (374)**

Kun Feng Wu, Tong Lin and Po-Jui Chen

**Investigating and Enhancing Non-Metro Trips and Life between Stations: Insights from Hong Kong (395)**
Yunting Miao and Jiangping Zhou

**A novel method for traffic state estimation in unmonitored network locations (444)**
Feng Xiao, Renbin Pan, Lu Li, Hegui Zhang and Minyu Shen

**Effects of weather conditions on pedestrian crossing risk perception at midblock: a cave-based simulator study (448)**
Manman Zhu and N.N. Sze

# ABSTRACTS

KEYNOTE SPEAKER SESSION

# THE PRICE IS RIGHT: TOWARDS A PRACTICAL AND ACCEPTABLE ROAD PRICING SCHEME

Michiel BLIEMER
*Institute of Transport and Logistics Studies,*
*University of Sydney*

Changes in the way we pay for road use seems inevitable because of shrinking revenues from fuel excise tax due to electrification of the vehicle fleet and because of the desire to move away from fixed annual vehicle registration fees that are not reflective of actual road use. The presentation will look at road pricing reform from multiple angles. First, results from a recent stated choice experiment in Australia regarding preferences towards various road pricing structures are discussed. Next, multiple road user charging strategies - distance-based pricing, mobility-based pricing, congestion pricing and marginal cost pricing - are assessed from a theoretical and practical point of view. Finally, traffic assignment outcomes on transport networks illustrate how each road user charging strategy impacts total travel time and distance differently, even at revenue neutral price levels.

# HIERARCHICAL CONTROL FOR LARGE-SCALE MULTI-MODAL URBAN NETWORKS

Nikolas GEROLIMINIS
*Urban Transport Systems Laboratory (LUTS),*
*École Polytechnique Fédérale de Lausanne (EPFL)*

Human mobility in congested city centers is a complex dynamical system with high density of population, many transport modes to compete for limited available space and many operators that try to efficiently manage different parts of this system. New emerging modes of transportation, such as ride-hailing and on-demand services create additional opportunities, but also more complexity. This talk will investigate hierarchical control strategies for two important applications, large-scale traffic signal control and repositioning of idle vehicles in ride-hailing systems (RHVs). First, we will design and investigate the effectiveness of a two-layer adaptive signal control framework for network-wide application, combining centralized macroscopic fundamental diagram (MFD)-based perimeter control with Max Pressure distributed control. Then, we will present a hierarchical control strategy for the repositioning of idle RHVs by integration of proactive macro-repositioning strategies and micro-management of vehicles partaking in such activities. The upper-layer utilizes an MFD aggregated model. Aggregated models for fleet management require more sophisticated MFD-based models describing mixed dynamics of private vehicles and RHVs. In the lower-layer, a coverage control scheme is employed to distribute the vehicles within the region to achieve a demand-aligned configuration, which provides each vehicle with relatively detailed position guidance. Results will be presented for both frameworks compared with traditional benchmark control strategies.

**DATA-FRIENDLY MESOSCOPIC NETWORK MODELING: LEARNING, PREDICTION, AND DECISION MAKING**

Sean QIAN
*Department of Civil and Environmental Engineering,*
*Heinz College of Information Systems and Public Policy,*
*Department of Electrical and Computer Engineering,*
*Carnegie Mellon University*

With the availability of various data sources across all modes of transportation systems, it remains a challenge how to take advantage of those diverse spatio-temporal data to best understand travel patterns across those modes in high spatio-temporal resolutions. In a mesoscopic network modeling framework, we formulate and solve for spatio-temporal passenger and vehicular flows in a multi-modal network explicitly considering solo-driving, public transit, parking, curb use and ride-sharing. Vehicular flows, namely vehicles in different classifications, are integrated in a holistic dynamic network loading (DNL) model. We further develop a general formulation of heterogeneous flow in their respective choices of modes, facilities and time. Through a computational graph approach, the travel behavior models and network characteristics can be jointly learned from a generic set of data, e.g. time-varying counts, speeds, census, transit data, and curb use data. Machine learning (ML) techniques are employed to optimally tune generic parameters to fit the multi-source data. This framework has been applied in many use cases for regions, cities and communities to make optimal decisions in transportation planning. The mesoscopic modeling approach can also be applied to real-time traffic operations, particularly early anomaly detection and proactive traffic management.

## SESSION A1: Urban Transit Systems Optimization

# OPTIMISING TIMETABLE SCHEDULES CONSIDERING NON-TRAFFIC HOUR MAINTENANCE WINDOW ON URBAN RAIL TRANSIT SYSTEM

A. Yaochen MA [a*], B. Hai WANG [b] and C. Hai YANG [a]

[a] *Department of Civil and Environmental Engineering, The Hong Kong University*

[b] *School of Computing and Information Systems, Singapore Management University, Singapore*

**Email: ymabv@connect.ust.hk (Corresponding author)*

Regular maintenance activities are essential to ensure resilience and prevent unexpected disruptions from the urban rail transit (URT) systems operation. However, the need for a non-traffic hour (NTH) maintenance window is sometimes expected to exceed the available time window, and adjustments to train service schedules by ending services earlier at night and/or starting later in the morning may be necessary. This study aims to integrally optimize the schedules of the last few late-night and the first few early-morning trains while meeting the requirement for NTH maintenance window. First, we present models and analytical results for the optimal late-night and early-morning train schedules on a single line when the two periods are separately optimized. Second, we incorporate the NTH maintenance window requirement into optimization. Four single adjustment schemes (ASs) are proposed, involving two action types: canceling train services or reducing train headways, and two action periods: late-night or early-morning. Then four pairwise comparisons are conducted. The case study, based on weekday and weekend passenger transaction data from Metro in Chengdu, China, presents numerical results of the optimal schedules and pairwise comparisons of ASs. It demonstrates that a mixed adoption of the adjustment schemes yields the optimal strategies. Our findings provide innovative analytical solutions to the pressing issue of extending the NTH maintenance window on URT systems, striking a balance among the objectives of multiple stakeholders. These include platform waiting times for late-night and early-morning passengers, operators' costs while maintaining sufficient NTH maintenance window, and penalties for unserved demand due to service unavailability.

Keywords: Late-night train timetabling; Early-morning train timetabling; Non-traffic hour (NTH) maintenance window; Urban rail transit systems.

# OPTIMIZING BUS DEPOT LOCATION AND BUS FLEET ALLOCATION FOR BOTH REGULAR BUS SERVICES AND BUS BRIDGING SERVICES IN RESPONSE TO URBAN RAIL TRANSIT DISRUPTIONS

A. Yunqiao XIANG [a], B. Yun WANG [a*], C. Xuedong YAN [a], D. Yu ZHOU [b]
and E. Qingwan XUE [c]

[a] *MOT Key Laboratory of Transport Industry of Big Data Application Technologies for Comprehensive Transport, School of Traffic and Transportation,*
*Beijing Jiaotong University, Beijing, China*

[b] *School of Transportation Science and Engineering, Beihang University, Beijing, China*

[c] *Beijing Key Laboratory of Urban Intelligent Traffic Control Technology,*
*North China University of Technology, Beijing, China*

**Email: wang.yun@bjtu.edu.cn (Corresponding author)*

The increasing reliance on urban rail transit (URT) means even brief interruptions can result in significant losses for both operators and passengers. Utilizing regular buses for bridging services has become a critical response to URT disruptions, but its impact on regular operations must not be overlooked. Integrated planning for buses and URT is essential. This paper focuses on optimizing bus depot locations and fleet allocation for regular bus planning in response to URT disruptions, within an integrated public transport context. The problem is formulated as a bi-objective programming model, aiming to reduce costs for both operator and passenger in regular transport and the unserved passengers in bridging services. An augmented ε-constraint method with lexicographic optimization and utopia point is proposed to achieve balanced Pareto optimal solutions. Tested on real data from the Nanchang public transportation network, our method quickly generates high-quality solutions for regular bus planning, ensuring the quality of regular bus services while accommodating bus bridging services.

Keywords: Regular bus planning; Bridging bus service; Bus depot location; Bus fleet allocation; URT service disruption

# SCHEDULING OF AUTONOMOUS MODULARIZED TRAINS UNDER VIRTUAL COUPLING SIGNALING

A. Maoning CHEN [a] and B. Hongbo YE [a*]
[a] *Department of Electrical and Electronic Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
[*] *Email: hongbo.ye@polyu.hk (Corresponding author)*

Virtual coupling (VC), as a new signaling system in railway, enables trains to run very close to each other. An autonomous modularized train (AMT) is a train unit or carriage that is self-propelled and be able to run autonomously without a human driver. AMTs combined with VC provide a new way to operate the railway system, which can improve the flexibility of organizing train services and increase the railway capacity. In this paper, we study how to schedule and operate the AMTs under VC to provide the inter-city railway services. We propose an optimization model for scheduling the AMTs to satisfy the spatial variation of passenger demand, considering platform restrictions, en-route coupling, decoupling, skip-stop, and overtaking, with the objective of minimizing total running time and finish time. Numerical experiments are conducted to verify the effectiveness of our model.

Keywords: Train Scheduling, Virtual Coupling, Autonomous modularized trains

# ANALYSIS OF URBAN RAIL TRANSIT RESILIENCE UNDER DIFFERENT OPERATION SCHEMES: A PERCOLATION-BASED APPROACH

A. Tianlei ZHU [a], B. Xin YANG [a*], C. Anthony CHEN [b], D. Guanwen ZENG [a]

B. and E. Jianjun WU [a]

[a] *School of Systems Science, Beijing Jiaotong University, Beijing, China*
[b] *Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hong Kong, China*
[*] *Email: xiny@bjtu.edu.cn (Corresponding author)*

Urban rail transit (URT) is a crucial infrastructure in modern megacities, playing a vital role in maintaining the basic functions of a metropolitan city. However, the current research still lacks a comprehensive understanding of the resilience analysis that considers overall system state under different operation schemes. Hence, this paper, grounded in percolation theory, comprehensively examines multiple sources of information and the operational characteristics of URT to develop a dynamic passenger-train coupled network (PTCN) model. This model integrates the overall network state to depict the resilience of various operating schemes within the URT system. We first observed percolation transition on the dynamic PTCN and analyzed the trends of daily resilience changes through the critical percolation threshold. And we characterized critical bottlenecks based on the changing properties of network phase transitions features. The results indicate that the resilience analysis framework can effectively depict the resilience changes of URT networks at different time periods.

Keywords: Urban rail transit, Percolation, Resilience assessment, Network bottlenecks, Operation schemes

# THE EFFECT OF EYE-LEVEL BUILT ENVIRONMENT ON METRO-BICYCLE INTEGRATION: INTEGRATING STREET VIEW IMAGES WITH DEEP LEARNING TECHNIQUES

A. Shuli LUO [a*]
*The Chinese University of Hong Kong, Shenzhen*
**Emai:* shuliluo@cuhk.edu.cn *(Corresponding author)*

The integration of metro and bicycle systems has emerged as a promising climate change mitigation strategy, promoting sustainable and active transportation in urban areas. While previous research has focused on macro-scale built environment factors, such as accessibility and land use mix, the influence of micro-scale or eye-level built environment features remains understudied. This study aims to investigate how these features impact metro-bicycle integration. Drawing on urban design and environmental aesthetics theories, the study explores how cyclists interpret visual elements of urban aesthetics and how these perceptions influence their travel behaviors. To analyze these features, advanced deep learning techniques are employed to analyze street view images, offering a novel approach. Additionally, metro-bicycle trip data from a comprehensive bike-sharing dataset in Suzhou, China is examined. A generalized additive mixed model (GAMM) is used to analyze the relationship between eye-level built environment features and metro-bicycle usage, considering spatial and temporal autocorrelations.This study contributes to the theoretical understanding of micro-scale environmental determinants of transportation behavior and informs evidence-based urban planning and policy-making. By optimizing the built environment around metro stations, interventions can be developed to enhance metro-bicycle synergy, promoting sustainable urban mobility.

Keywords: Metro-bicycle integration, street view images, eye-level built environment, deep learning, sustainable transportation

SESSION A2: Maritime Transport and Port Capacity

# EXTRACTING MARITIME TRAFFIC ROUTE NETWORK FROM AUTOMATIC IDENTIFICATION SYSTEM (AIS) DATA

A. Shuo JIANG [a], B. Poong OH [b] and C. Ran YAN [a*]

[a] *School of Civil and Environmental Engineering, Nanyang Technological University, Singapore*

[b] *Wee Kim Wee School of Communication and Information, Nanyang Technological University, Singapore*

**Email: ran.yan@ntu.edu.sg (Corresponding author)*

Understanding maritime traffic patterns and analyzing the complex networks formed by shipping lanes are critical for maritime safety, operations, and policy making. In this study, we propose a framework that uses Automatic Identification System (AIS) data to extract primary shipping lanes in a designated maritime region and conduct a comprehensive analysis of the interwoven network formed by these lanes. Using publicly available AIS data in the Mediterranean region for from April 1st, 2015 to April 28th, 2015 as a case study, we employ self-organizing map (SOM) neural networks to identify and characterize the main shipping lanes traversing the area. Furthermore, we employ network analysis methodologies to examine the intricate web of connections formed by these shipping lanes. Through network metrics and visualization techniques, we uncover the structural properties, centrality measures, and spatial distribution patterns of the maritime network. This study offers insights into the connectivity and resilience of regional shipping network, providing valuable knowledge of optimizing shipping routes and enhancing operational efficiency for maritime stakeholders and decision-makers.

Keywords: AIS data, Network Analysis, Vessel trajectories, Maritime transport

# BOUNDS AND APPROXIMATIONS FOR PORT CAPACITY WITH TWO-WAY CHANNELS

A. Xiaokuan ZHAO [a*] and B. Weihua GU [a]
[a] *Department of Electrical Engineering, The Hong Kong Polytechnic University, Hong Kong SAR, China*
[*] *Email: xiaokuan98.ZHAO@connect.polyu.hk (Corresponding author)*

Evaluating port capacity is crucial for optimizing shipping operations and enhancing efficiency in maritime logistics. This paper focuses on analyzing the capacity of ports under different scenarios. However, previous research has paid limited attention to analytically modeling the capacities of different configurations, such as the number of berths. In this study, we apply a mathematical analysis method based on queueing theory to analyze the port capacity of both single-berth and multiple-berth ports with two-way channels. We investigate several specific scenarios to derive bounds for port capacity under different operational conditions. By utilizing vessel trajectories and probabilistic methods, assuming vessel arrivals and service processes as Poisson processes, we calculate Poisson approximations for port capacity. These approximations are validated through simulations, which demonstrate a high level of accuracy. Furthermore, we conduct numerical case studies to examine the impact of various operational factors on port capacity. The findings provide valuable insights and practical implications for effective port management.

Keywords: port capacity, queueing system, bounds, Poisson approximation, two-way channels

# HOW DOES SHIPPING ALLIANCE AFFECT PORT CAPACITY INVESTMENT AND CONGESTION

A. Tianyu SHANG [a], B. Hao WU [b], C. Dong YANG [a], D. Changmin JIANG [a] and E. Kun WANG [c*]

[a] *Department of Logistics and Maritime Studies,*
*The Hong Kong Polytechnic University, Hong Kong, China*
[b] *School of International Trade and Economics,*
*University of International Business and Economics, Beijing, China*
[c] *Department of Industrial and Systems Engineering,*
*The Hong Kong Polytechnic University, Hong Kong, China*
[*] *Email: allen-kun.wang@polyu.edu.hk (Corresponding author)*

The container shipping sector has experienced significant growth through the development of the shipping alliances, which enables the shipping lines to share capacity and improve vessel coordination. These alliances can achieve economies of scale, attract more traffic volume, and realize better coordination of ship size and movements. As a result, the shipping alliance could affect port congestion by impacting port capacity investment, traffic volume, and ship movements. This is the first study to analyze this topic, in which an integrated economic model is built to consider the strategic interactions between shipping lines (alliance vs. without alliance) and the port. Our model incorporates two key impacts of the shipping alliance on port capacity investment: (i) the impact of economies of scale and the resultant lower operating cost; and (ii) the improved shipping lines' ability to reduce congestion due to the employment of larger ships/better coordination. The former could encourage more capacity investment, while the latter might lead to reduced investment as shipping lines become more adept at managing congestion after forming the shipping alliance. We find that whether capacity investment will increase depends on the relative dominance of these two effects. Furthermore, we also find that port congestion may not necessarily decrease in presence of the shipping alliance, with the influence of economies of scale, improved congestion reduction abilities of the shipping lines, and port capacity investment. Among them, we find that the increase in port capacity investment in the case of shipping alliance may not be sufficient to reduce congestion.

Keywords: port congestion, port capacity investment, shipping alliance, shipping line, economic modelling

As at December 7, 2024

# ECONOMIC ANALYSES ON ELECTRIC SHIPS ADOPTION IN INLAND WATER TRANSPORT AND GOVERNMENT'S OPTIMAL SUBSIDY SCHEME DESIGN

A. Ziyu CUI [a], B. Xiaowen FU [a], C. Xiangru WU [a] and D. Kun WANG [a*]
[a] *Department of Industrial and Systems Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
[*] *Email: allen-kun.wang@polyu.edu.hk (Corresponding author)*

To foster the electrification of inland maritime transport, governments are exploring various subsidy policies to effectively support the adoption of electric ships. This paper proposes a game-theoretic model for optimizing government subsidy schemes, considering the interactions among the government, port operator, shipping company, and shipper. Three widely adopted subsidy schemes, i.e., subsidy for charging station investment, subsidy for purchasing electric ships, and subsidy for electricity fees, are analytically discussed and compared in the game-theoretic model. In this model, the government determines the optimal subsidy scheme and amount of subsidy to maximize social welfare. The port operator decides the investment level of charging stations and the price of electricity to maximize its net profit. Furthermore, this study investigates the optimal subsidy policy under different levels of charging efficiency. The analytical results show that both investment and usage subsidies are equally effective in improving the investment level, consumer surplus, company profits, port profits, and social welfare. However, with higher charging efficiency, investment subsidies are most conducive to maximizing social welfare, whereas usage subsidies are preferable for optimizing consumer welfare or social welfare at a lower level of charging efficiency. These insights provide crucial guidelines for governments aiming to design optimal subsidy schemes that achieve varied objectives in promoting environmentally sustainable electric ships.

Keywords: Electric ships, Charging infrastructure, Subsidy schemes, Social welfare, Game theory

# TRANSITION TO AN ALTERNATIVE-FUEL TUGBOAT FLEET THROUGH TWO-STAGE ROBUST OPTIMIZATION MODELING

A. Jing WANG [a], B. Shuai JIA [a, b*] and C. Yibai (Minwhyte) ZHANG [b]
[a] *Department of Civil and Environmental Engineering,*
*The Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong*
[b] *Thrust of Intelligent Transportation,*
*The Hong Kong University of Science and Technology (Guangzhou), Guangzhou, 511453, China*
[*] *Email: shuaijia@hkust-gz.edu.cn (Corresponding author)*

The harbour craft in the port is identified as as key contributors to meeting the International Maritime Organization's (IMO) greenhouse gas emission reduction targets for 2030 and 2050. Renovation of the existing harbour craft by alternative fuel transitions is highlighted as a significant focus for decarbonization from a range of cleaner energy pathways. In this paper, we study the decarbonization strategies for tugboat fleet, which plays a crucial role in port operations, by optimizing through upgrades and the integration of new vessels powered by six prominent cleaner fuels: biodiesel, liquefied natural gas (LNG), methanol, hydrogen, ammonia, and electricity. We propose a two-stage robust optimization model for decisions of sub-fleets sizing powered by these alternative fuels, taking into account the demand uncertainty. An adapted column-and-constraint generation method is developed to obtain solutions with minimum total cost. We provide an exhaustive analysis of the feasibility of these alternative fuels in terms of operational performance, technical requirements, environmental impact, and techno-economic viability for the integrated tugboat fleet. A tailored fuel consumption model is proposed for emission assessment due to tugboats' unique operational profiles. The models and solutions can be applied to tackle problem instances that are generated from the Automatic Identification System (AIS) data of tugboats operating in the Port of Singapore.

Keywords: port decarbonization, tugboat fleet, alternative fuel, CO2 emissions, robust optimization

## SESSION A3: Data-Driven Traffic Flow Modeling

### TDI: HIGH-RESOLUTION TRAJECTORY BASED DEBRIS IDENTIFICATION ALGORITHM FOR HIGHWAY EVENT MANAGEMENT SYSTEM

A. Dongyu TIAN [a*], B. Ruyi FENG [a*], C. Zhibin LI [a*], D. Shunchao WANG [a]
and E. Si ZHENG [a]
[a] *Transportation School, Southeast University, China*
**Email: tiandongyu@seu.edu.cn; fengruyi@seu.edu.cn; lizhibin@seu.edu.cn*
*(Corresponding authors)*

Debris on highways can prompt sudden braking and emergency lane changes of vehicles, potentially resulting in accidents and traffic disruptions. Due to the diverse visual characteristics and few occurrences of different debris, direct detection based on computer vision still presents significant challenges. Even so, under adverse conditions, such as rainy days or nighttime with poor image quality, it becomes even more challenging to identify debris and promptly remove it. To increase the accuracy of debris detection and help free up labor, a novel trajectory-based debris identification(TDI) algorithm through online vehicle trajectory analysis has been proposed. The algorithm was specifically tailored to utilize automatically extracted high-resolution trajectory data to identify the debris that might influence vehicle movement. The algorithm is based on a road cellular model and identifies the existence of debris by discerning the intensity of evasive or lane-changing behaviors. This eliminates the dependency on visual characteristics of debris and image quality for detection. Currently, the TDI algorithm has been tested as a co-pilot of the traffic management department for months. The field test data is from 10 radar devices on the ring road expressway at a frequency of 20FPS, covering a road segment length exceeding 7000 km. It can operate online around the clock and can detect multiple roadside devices with a frame rate of 40 FPS. It demonstrated a detection recall of 86% and significantly reduced the detection time by 70% of debris only identified by humans.

Keywords: debris detection, vehicle trajectory analysis, ITS, road cellular model

# A BI-LEVEL CALIBRATION METHOD OF MICROSCOPIC CAR-FOLLOWING MODELS BASED ON DYNAMIC TRAFFIC FLOW

A. Hyeokju Nam [a], B. Jihye Byun [a], C. Dong Ngoduy [b] and D. Seunghyeon Lee [a*]

[a] *Department of Transportation Engineering, The University of Seoul, Republic of Korea*

[b] *Department of Civil Engineering, Monash University, Australia*

[*]*Email: seunghyeon.lee@uos.ac.kr (Corresponding author)*

In this study, we propose a novel bi-level structure that involves the clustering of traffic data and the subsequent calibration of Intelligent Driver Model (IDM) parameters. This approach aims to enhance the performance of the conventional IDM, which utilizes fixed parameters across the entire dataset. There are three challenges to design an iterative bi-level IDM calibration process that involves traffic states clustering. First, K-means algorithm is adopted to cluster traffic states from the vehicle trajectory data according to the Fundamental Diagram (FD). Furthermore, for each clustered traffic state group, the calibration process of the IDM is conducted using Genetical Algorithm (GA). In addition, the entire process is iterated, computing a loss function based on the comparison with the ground truth data for optimizing the clustered groups and the parameters of IDM. The trajectory datasets are extracted from the NGSIM US 101 dataset. The dataset is adopted to train the parameters of IDMs through the suggested calibration method, specifically focusing on trajectory data from 7:50 A.M. to 8:05 A.M., to effectively capture dynamic features of individual vehicle's traffic flow. The results have shown that the model accurately provides IDM parameters that illustrate traffic states and helps in a better understanding of the vehicular platooning features. This study highlights the potential of car-following models with individually calibrated parameters for each traffic cluster, enabling their implementation across various traffic states. Furthermore, this bi-level calibration method paves the way for future research to study diverse conditions for vehicular platooning strategies, considering dynamic traffic flow.

Keywords: Traffic data clustering, Model calibration, Dynamic traffic flow, Car-Following model

# A HYBRID NEURAL NETWORK FOR REAL-TIME OD DEMAND CALIBRATION UNDER DISRUPTIONS

A. Takao DANTSUIJ [a*], B. Dong NGODUY [a*], C. Ziyuan PU [a], D. Seunghyeon LEE [b] and E. Hai L. VU [a]

[a] *Monash Institute of Transport Studies, Monash University, Australia*

[b] *Department of Transportation Engineering, The University of Seoul, Korea*

**Email: Takao.Dantsuji@monash.edu; Dong.Ngoduy@monash.edu (Corresponding author)*

Existing automated urban traffic management systems, designed to mitigate traffic congestion and reduce emissions in real time, face significant challenges in effectively adapting to rapidly evolving conditions. Predominantly reactive, these systems typically respond to incidents only after they have transpired. A promising solution lies in implementing real-time traffic simulation models capable of accurately modelling environmental changes, thereby minimising the adverse effects of disruptions on traffic flow and driver experience. Central to these real-time traffic simulations are origin-destination (OD) demand matrices. However, the inherent variability, stochasticity, and unpredictability of traffic demand complicate the precise calibration of these matrices in the face of disruptions. this paper introduces a hybrid neural network (NN) architecture designed for real-time OD demand calibration to enhance traffic simulations' accuracy and reliability. The proposed hybrid NN predicts the OD demand to reconcile the discrepancies between actual and simulated traffic patterns. To facilitate real-time updating of the internal parameters of the NN, we develop a metamodel-based backpropagation method by integrating data from real-world traffic systems and simulated environments. This ensures precise predictions of the OD demand even in the case of unpredictable traffic patterns. Furthermore, we incorporate offline pre-training of the NN using the metamodel to improve computational efficiency. Validation through a Tokyo expressway corridor case study illustrates the model's ability to dynamically adjust to shifting traffic patterns across various disruption scenarios. Our findings underscore the potential of advanced machine learning techniques in developing proactive traffic management strategies, offering substantial improvements over traditional reactive systems.

Keywords: real-time traffic simulation; OD demand calibration; on-line learning; neural network; metamodel-based backpropagation

# VALIDATION OF AN INNOVATIVE CAR-FOLLOWING MODEL USING GNNS AND PINNS WITH MULTI-MODAL AI ON ON-BOARD DIAGNOSTICS

A. F. FURUHASHI [a*]

[a] *Department of Civil Engineering, The University of Tokyo, Tokyo, Japan*

[*] *Email: furuhashi@bin.t.u-tokyo.ac.jp (Corresponding author)*

This study proposes an innovative approach to modeling and predicting complex car-following behaviors within traffic flow by integrating Graph Neural Networks (GNNs) with Physics-Informed Neural Networks (PINNs). Traditional microscopic traffic flow models, such as the Kometani-Sasaki's car-following model and the Gazis-Herman-Rothery (GHR) model, are effective in capturing interactions between two vehicles but fall short in accurately modeling the intricate interactions within a platoon. To address this limitation, we combine a Graph Attention Transformer (GAT) with a Temporal Convolutional Network (TCN) to predict ego vehicle speed. The GAT effectively represents vehicle interactions in a platoon as a graph, while the TCN flexibly processes time-series data. By embedding physical laws through the PINN, this model achieves high accuracy and robustness. Numerical experiments using extensive driving data from the Tomei and Shin-Tomei Expressway demonstrate that the GNN+PINN model significantly outperforms traditional approaches, such as GHR model-based equations and conventional machine learning models represented by LSTMs, particularly in scenarios where the headway varies. These results highlight the potential of this novel approach to extend the existing framework of car-following theories, which typically describe interactions between two vehicles, to model the complex interactions among multiple vehicles. This advancement underscores the applicability of the model to real-world traffic management systems aimed at improving traffic flow prediction.

Keywords: Physics-Informed Neural Networks (PINNs), Graph Neural Networks (GNNs), Car-Following Theory, Traffic Flow, Trajectory Prediction

# A LEARNING NETWORK VIA MULTI-STAGE SPATIAL–TEMPORAL FEATURE SELECTION FOR SHORT-TERM TRAFFIC FLOW PREDICTION

A. B. Wang [a], B. J. Zhang [a,b*], C. R. Zhao [a] and D. K. Zhang [a]
[a] *Jiangsu Key Laboratory of Urban ITS, Department of Intelligent Transportation and Spatial Informatics, School of Transportation, Southeast University, Nanjing 211189, China*
[b] *Institute of Technology, Tibet University, Lhasa, Tibet, 850000, China*
**Email: jianzhang@seu.edu.cn (Corresponding author)*

The accurate selection of spatial-temporal features is key for the short-term traffic flow prediction model to output higher quality results, which can effectively reduce the difficulty of constructing the prediction model. The spatial-temporal feature selection in most existing short-term traffic flow prediction models mainly relies on empirical knowledge methods and lacks the fusion of external factors. A learning network via multi-stage spatial-temporal feature selection (LN-MSTFS) is proposed, where LN-MSTFS is divided into initial temporal-spatial feature set generation, filtering, feature optimization, and predicted model stages. Three widely used feature selection methods for short-term traffic flow prediction are applied and compared. The three experimental targets and four types of time granularity are assessed using two evaluation indexes in actual potential usages. The results show that the LN-MSTFS method has an overall superior performance, good interpretability, and readability for selected spatial-temporal features. The weighted mean relative error (WMRE) at 5 minutes, 15 minutes, 30 minutes, and 60 minutes have roughly averaged 11.48%, 8.56%, 7.84%, and 6.54% respectively.

Keywords: Feature selection, short-term traffic flow prediction, machine learning, LSTM

SESSION A4: Multimodal Transport Systems Optimization

# ADAPTIVE ROUTING AND SCHEDULING OF NETWORK-WIDE RAIL TRANSIT SERVICES WITH FLEXIBLE TRAIN COMPOSITION

A. Shou-yi WANG [a] and B. Andy H.F. CHOW [a*]

[a] *Systems Engineering, City University of Hong Kong, Kowloon Tong, Hong Kong SAR*

**Email: andychow@cityu.edu.hk (Corresponding author)*

This paper presents a novel adaptive control framework with flexible train composition for routing and scheduling in network-wide rail transit services. This framework aims to minimize passenger waiting times and operating costs driven by stochastic travel demand. The control problem is formulated as a partially observable Markov decision process (POMDP) to reflect the practicality in real-world applications. To address the computational challenges associated with solving the POMDP, deep reinforcement learning techniques are applied to seek potential optimal solutions to the optimization problem. The proposed control framework is tested using real-world scenarios and the data collected from the Hong Kong Light Rail Transit (LRT) network. The experiment results demonstrate that the proposed routing and scheduling control framework using flexible train composition can effectively reduce passenger waiting time and operating costs. This study contributes to the real-time routing and scheduling of network-wide rail transit services by integrating advanced optimization technology.

Keywords: transit routing, service scheduling, flexible train composition, Markov decision process, reinforcement learning

# A BI-LEVEL OPTIMIZATION MODEL FOR MULTIMODAL TRANSPORT RESOURCE ALLOCATION AND PRICING CONSIDERING SHIPPER PREFERENCE

A. Yingming YAO [a], B. Xiang ZHANG [a,b*], C. Jingwen LI [a] and D. Fengxin DAI [a]
*[a] College of Transportation Engineering, Dalian Maritime University, Dalian, 116026, China [b] School of Civil and Environmental Engineering, University of New South Wales, Sydney, 2052, Australia*
**Email: xiang.zhang@dlmu.edu.cn (Corresponding author)*

This paper proposes a bi-level model to address the problem of multimodal transport resource allocation and pricing, considering shipper preference. In the upper-level model, each multimodal transport integrator achieves its profit maximization while satisfying the demands of shippers by integrating the railway, highway, and maritime transport resources offered by various transport service providers. The pricing of integrators is not only influenced by the cost of their services but also by competitors, so there is a Nash game between integrators. The Nash equilibrium is reached when the shipper's choice does not change due to any integrator changing the pricing. The lower level model uses the logit model to estimate the probability of choosing an integrator to determine the shipper's choice. First, we use the Large Neighborhood Search to calculate the integrator's pricing and profit for different multimodal transport services under the condition that the integrator's profit before and after two times is less than 5%, and at the same time give the shipper's selection probability. Then we use the Monte Carlo tree search algorithm to solve the pricing game and calculate the final pricing. Finally, the Yangtze River Delta region is selected for numerical experiments to verify the effectiveness of the model. This paper analyzes the effect of the change in the proportion of goods with different time costs and reliability costs on the pricing strategy and profit of multimodal transport integrators. At the same time, the sensitivity analysis of unit transport cost between different modes of transport is carried out.

Keywords: A bi-level model; Multimodal transport resource allocation; Pricing game; Shipper preference

# INTEGRATED DESIGN OF URBAN RAIL TRANSIT FED BY FEEDER BUS AND SHARED BIKE

A. Miaoqing, HU [a*] and B. W. Y. SZETO [a*]
[a] *Department of Civil Engineering, The University of Hong Kong, China*
**Email: mqhu0909@connect.hku.hk; ceszeto@hku.hk (Corresponding author)*

The increasing scale of the city generates a greater demand for long-distance travel among different districts, making public transit play an important role in the daily mobility of residents. In practice, transit operators often provide both long-haul trunk services (e.g., metro) and short-haul feeder services (e.g., community bus and shared bike). Passengers need to make transfers at major transfer stations to finish their trips. This paper proposes a bi-level nonlinear mixed-integer model to design long-haul transit and feeder service simultaneously. To reflect the relationship between different modes, a multimodal transportation network is considered comprising metro, feeder bus, bike, and walking. The base model is designed to address an integrated optimization problem, aiming to maximize social welfare, and two derived models are introduced to accommodate other operator assumptions. A modified genetic algorithm (GA) that encapsulates the fixed-point iteration and method of successive algorithm (MSA) is developed to solve the model. The comparison between integrated design and separated design with different operators are conducted to analyze the gain and loss of each party. Numerical examples are given to investigate the factors that affect the integrated design.

Keywords: station location design, feeder bus service, shared bike, metro alignment design, multimodal network design

# OPTIMAL TRUNK-FEEDER TRANSIT NETWORK DESIGN UNDER HETEROGENEOUS DEMAND

A. Li ZHEN [a*] and B. Weihua GU [a]

[a] *Department of Electrical and Electronic Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*

[*] *Email: l-i.zhen@connect.polyu.hk (Corresponding author)*

With the extension of urbanization, enhancing efficient trunk-feeder transit systems becomes crucial to accommodate the escalating travel demand. A well-designed trunk-feeder network not only improves travel efficiency on trunk lines but also bolsters connectivity and flexibility through feeder services. In this paper, based on the heterogeneity of travel demand, we optimize a heterogeneous trunk-feeder transit network design using continuous models. Our model entails a two-pronged strategy: on the one hand, addressing the spatial heterogeneity in rail trunk line design, which encompasses heterogeneous line and stop spacings and service headways; on the other hand, contemplating the heterogeneity of feeder service modes, including fixed-route feeder buses, flex-route feeder buses, shared bikes, and walking, while optimizing the design parameters for each type of feeder service. This study pioneers a model that simultaneously integrates heterogeneous trunk-line designs and multiple feeder service modes. This innovative model advances beyond previous studies that predominantly focused on homogeneous transit network designs or single feeder service modalities. Numerical experiments demonstrate that our model yields significant cost reductions compared to outcomes from prior studies.

Keywords: transit network design, trunk-feeder system, feeder service, continuous model, heterogeneous demand

# JOINT OPTIMIZATION OF SEAT ALLOCATION AND PRICING WITH MULTI-RIDE SEASON TICKET SERVICE IN THE HIGH-SPEED RAIL SYSTEM

A. Runfa WU [a], B. Wei LIU [a*] and C. Yuzhen FENG [a]

[a] *Department of Aeronautical and Aviation Engineering*

*The Hong Kong Polytechnic University, Hong Kong SAR, China*

[*] *Email: wei.w.liu@polyu.edu.hk (Corresponding author)*

With the rapid expansion of the network and the continuously increasing service capacity in the high-speed rail (HSR) industry, operators are introducing innovative services to attract passengers. Season ticket services enhance flexibility for passengers in HSR systems and hold the potential to augment operator revenues. This paper jointly optimizes the seat allocation and pricing problem when the HSR system provides ordinary and multi-ride season ticket services simultaneously. Specifically, we consider the season ticket service that offers a specific number of travels within a defined period between two stations without a seat reservation. In this context, a bi-level model is proposed that optimizes the seat allocation plans and related prices for both ordinary and season tickets in the upper level, and the lower level employs the joint user equilibrium approach to model passenger demands and travel decisions. The model accounts for the shared seat capacity on HSR trains by passengers holding two types of tickets, we also discuss the uniqueness/non-uniqueness properties of the equilibrium for passengers' travel choices. A gradient projection-based solution procedure is proposed to solve the bi-level model, incorporating sensitivity analysis on the lower-level equilibrium and a backtracking line search. Numerical results are presented to illustrate the model and proposed solution procedure, a large-scale instance in the real HSR scenario demonstrates that the proposed approach can provide decision support for the operator after introducing the innovative multi-ride season ticket service.

Keywords: Multi-ride season ticket, High-speed rail, Pricing, Seat allocation, Passenger equilibrium

## SESSION A5: E-Bike Sharing System Optimization

# UNDERSTANDING PUBLIC BIKE TICKET CHOICE WITH HOURLY TRAVEL DISTANCE PATTERNS: A CASE STUDY OF SEOUL PUBLIC BIKE SYSTEM

A. Taewoo KIM [a], B. Jonghan PARK [a] and C. Joonho KO [a*]

[a] *Department of Urban and Regional Development, Graduate School of Urban Studies, Hanyang University, Seoul, South Korea*

[*] *Email: jko@hanyang.ac.kr (Corresponding author)*

The bike-sharing system (BSS) has become a vital mode of transportation in mega-cities worldwide. However, many cities face sustainability challenges in BSS operations. To stabilize these systems, it is crucial to analyze users' ticket choices. While previous studies have explored factors influencing ticket selection, most have focused solely on the ticketing system itself. This study presents a comprehensive approach to understanding ticket choice by integrating socio-demographic data and rental records Our methodology involved three key steps. First, we clustered BSS users based on their usage patterns across four time intervals on weekdays. Second, we conducted a factor analysis using survey data to derive a latent variable representing personal preferences toward BSS usage. Finally, we combined the survey and rental record data to perform a multinomial logistic regression analysis, examining the factors influencing ticket choices. The findings reveal that users' selections of BSS seasonal tickets are strongly influenced by their socio-demographic characteristics and usage patterns. Additionally, the duration of the chosen seasonal tickets varies significantly based on these characteristics. This research underscores the importance for BSS operators to better understand their target users and to develop tailored seasonal ticket strategies that enhance user engagement and promote a financial system sustainability.

Keywords: Bike sharing system, Hourly travel patterns, Travel behavior, Clustering, Multinomial logistic regression

# AN E-BIKE REPOSITIONING PROBLEM WITH CHARGING AND NON-CHARGING DOCKS

A. Mingxuan CHEN [a*] and B. W.Y. SZETO [a*]
[a] *Department of Civil Engineering, The University of Hong Kong, China*
[*] *Email: mingxuan@connect.hku.hk; ceszeto@hku.hk (Corresponding authors)*

E-bikes have recently been offered by many bike sharing operators to improve the mobility and reduce the strain of riding compared to conventional shared bikes. The charging problem of e-bikes has been mainly considered to be handled by battery swapping, with less attention on charging the e-bikes using charging docks. This study investigates an e-bike repositioning problem (EBRP) with charging and non-charging docks with the objective of minimizing the weighted sum of the total penalty that incorporates e-bikes with adequate or inadequate batteries, the total travel time, and the total loading, unloading, and moving time. The effects of the percentage of charging docks and the repositioning time budget are tested. In dealing with the loading, unloading, and moving subproblem, which is complicated by charging operations on top of repositioning operations, a heuristic is designed to solve subproblem effectively. Problems with large network sizes can be efficiently solved by incorporating the heuristic in hybrid genetic search (HGS).

Keywords: Bike sharing system, E-bike repositioning problem, Charging docks, Tailor-made heuristics

# ELECTRIC ASSISTANCE OFFERS GREATER TEMPERATURE RESILIENCE FOR ACTIVE TRAVEL MODES: EVIDENCE FROM CITI BIKE IN NEW YORK CITY

A. Rong ZHENG [a], B. Yuan LIANG [a] and C. Donggen WANG [a*]

[a] *Department of Geography, Hong Kong Baptist University, Hong Kong SAR, China*

[*] *Email: dgwang@hkbu.edu.hk (Corresponding author)*

Active travel offers advantages in terms of affordability, health benefits, low emissions, and climate mitigation contributions. Nevertheless, active travelers often suffer from discomfort and health risks under extreme temperatures. Existing research has primarily focused on the overall temperature effects on active travel, with limited investigation into how the temperature resilience of active travelers can be improved. To address this gap, with the trip data of Citi Bike in New York City in 2023, we examined if shared e-bikes help people cope with extreme temperatures better than shared bikes. After aggregating the mobility data and weather data into the zip code tabulation area (ZCTA) and controlling various covariates, we adopted a binned fixed-effects panel regression model to assess the temperature resilience which reflects the relationship between hourly temperature fluctuations and ridership changes. The results reveal similar nonlinear effects of temperature on both shared bikes and shared e-bikes. Notably, shared e-bikes exhibit significantly higher temperature resilience than shared bikes, outperforming by 5.6% in hot conditions (30–32°C) and by 7.5% in cold conditions (-2–0°C). This suggests that semi-active travel modes offer superior temperature resilience. Moreover, the temperature resilience disparities between shared e-bikes and shared bikes perform heterogeneities across different trip properties and socio-economic demographics. Our findings suggest that, integrating electric assistance into shared micromobility systems is a good strategy for building climate-resilient mobility systems and improving active travel temperature resilience, particularly for the area with more socioeconomic disadvantages.

Keywords: Climate Change, Temperature Resilience, Shared Micromobility, Active Travel, Shared Bikes, Shared E-bikes

# A HYBRID E-BIKE SHARING SYSTEM DESIGN PROBLEM CONSIDERING MULTIPLE TYPES OF FACILITIES

A. Jiatong SONG [a], B. W.Y. SZETO [a*], C. Baicheng LI [b] and D.Yi WANG [c]
[a] *Department of Civil Engineering, The University of Hong Kong, China*
[b] *College of Urban Transportation and Logistics, Shenzhen Technology University, China*
[c] *Department of Civil and Natural Resources Engineering, University of Canterbury, New Zealand*
**Email: ceszeto@hku.hk (Corresponding author)*

Shared electric bikes (e-bikes) have become a rapidly growing mode of transportation worldwide, with electric bike-sharing systems (EBSSs) successfully implemented in numerous cities. The fast development has spurred the emergence of new bike-sharing schemes, such as free-floating sharing systems, to compete with conventional station-based systems. However, existing studies primarily focus on single system types, without considering the need for a comprehensive mathematical model capable of optimizing the design of the hybrid EBSSs (HEBSSs). The HEBSSs encompass various decisions including the location and capacity designs of parking and charging facilities, as well as considerations of irregular parking behavior, waiting time costs at rental nodes, and parking rewards and fines. In this paper, we formulate this design question as a bi-level optimization problem. The upper-level problem is to determine the locations and capacities of various facilities, aiming to minimize social cost under a budget constraint, while the lower-level problem is an e-bike sharing network equilibrium problem. The upper-level problem is solved by the Genetic Algorithm (GA) coupled with a capacity setting heuristic, while the Self-Regulated Averaging Method (SRAM) is applied to tackle the lower-level problem. We present numerical examples to demonstrate the properties of the problem, illustrate the performance of the solution algorithm, and provide design insights into the planning of the HEBSSs.

Keywords: Facility location and capacity designs; bi-level optimization; e-bike sharing system; parking and charging facility; user-equilibrium.

# REPOSITIONING IN BIKE SHARING SYSTEMS WITH BROKEN BIKES CONSIDERING ON-SITE REPAIRS

A. Runqiu HU [a*] and B. W. Y. SZETO [a*]
[a] *Department of Civil Engineering, The University of Hong Kong, Hong Kong SAR, China*
**Email: runqiuhu@connect.hku.hkl; ceszeto@hku.hk (Corresponding author)*

The Bike Repositioning Problem (BRP) has gained increasing attention from researchers, but studies considering broken bike handling are limited. Current research mainly focuses on collecting broken bikes for off-site repairs, overlooking on-site repairs by maintenance workers. In practice, repairmen repair broken bikes directly at stations, alleviating the burden on vehicles repositioning both broken and usable bikes. A methodology combining usable bike repositioning, broken bike collection, and on-site repairman routing is needed to improve efficiency.This study presents a Mixed Integer Linear Programming (MILP) model for a static BRP incorporating vehicle-based bicycle delivery/collection and labor-based on-site repairs. The model minimizes total penalty costs of user dissatisfaction and carbon emissions during repositioning, subject to time constraints. Experiments on a small network demonstrate the benefits of on-site repairmen in improving performance, with lower user dissatisfaction compared to models without on-site repairs. As broken bikes increase within a range, on-site repairs can supplement stations lacking bikes, reducing truck visits and emissions. An algorithm combining a hybrid genetic algorithm and a enhanced greedy heuristic was developed to solve larger networks with varying truck and repairman numbers, demonstrating its performance. The findings prove the effectiveness of the algorithm in solving large instances.

Keywords: Bike Repositioning Problem; Broken Bike Repositioning; On-site Repair Routing

## SESSION A6: OSPA and ODA Presentations

# RHYTHMIC CONTROL METHODOLOGY FOR URBAN TRAFFIC NETWORKS UNDER A CONNECTED AND AUTOMATED ENVIRONMENT

A. Xiangdong CHEN [a] *
[a] *Department of Civil and Environmental Engineering,*
*National University of Singapore, Singapore 117576, Singapore*
* *Email: cxd@nus.edu.sg*

The rapid development of connected and automated technologies brings great potential for advanced urban traffic control. Considering the traffic problems of complicated conflict relations among vehicular movements, imbalanced distribution of traffic flows, and incompatibility of heterogeneous vehicles, this dissertation aims to develop an innovative rhythmic control method under a connected and automated vehicle environment to improve traffic efficiency and safety. To achieve the research objectives, this dissertation begins with the fundamental concept and model of rhythmic control, extends to various methods for different traffic scenarios. The main contents are summarized as follows:

(1) The novel and fundamental rhythmic control philosophy is proposed for single intersections. By in-depth examining the relationship of vehicular conflicting movements, the road geometric layout and traffic control strategy are designed in a unified framework. The concept of virtual container is introduced to organize traffic in a highly-orderly manner, and jointly optimized with the intersection geometric layout, so the right-of-ways of intersection could be finely assigned and the space-time resources could be fully utilized. The approach could reduce the average vehicular delay to below 10 seconds when the traffic saturation level reaches 90%.

(2) The fundamental rhythmic control strategy is extended over an urban network. A knot-type intersection design is proposed to simplify the conflicting relations, and collaborated among adjacent intersections. The two-phase traffic control strategy is developed and achieves the nearly-optimum throughput of intersections. The knot-type intersection design, space-time trajectories of virtual containers and network traffic flow assignment are jointly optimized to build up a network-level traffic control optimization model. The results show that the maximum traffic volume under rhythmic control strategy is twice as much as that under traditional signal control.

(3) The multiple rhythmic control method is proposed for an urban network with imbalanced traffic distribution. Differential control rhythms are adopted for different areas according to the flow distribution, and various virtual containers are designed for different types of vehicles. Collaborated with lane configuration and traffic flow assignment, a joint optimization model is developed for the heterogeneous traffic control. The approach could reduce vehicular travel cost and improve network throughput under various demand cases.

(4) The asynchronous rhythmic control method is proposed for the multi-mode traffic with transit buses and private cars. Dedicated virtual containers are designed for transit buses to provide priority of right-of-ways, and the travel itinerary planning of buses and the traffic flow assignment of private cars are jointly optimized. The results show that under the premise of priority treatment for buses, the method could eliminate the efficiency damage for private cars and enhance the overall traffic efficiency.

On the whole, this dissertation focuses on rhythmic control, and follows the main line that begins with fundamental philosophy, optimization models, and ends with simulation validation, and develops a complete solution of urban traffic control approach under the connected and automated environment. The proposed methods are expected to provide important reference significance for solving the current traffic problem and adapting to the future traffic development in urban cites.

# ON THE NETWORK EQUILIBRIUM OF AN INTEGRATED AIR-GROUND URBAN TRANSPORT SYSTEM

A. Zhenwei GONG [a], B. Zhuoye ZHANG [a] and C. Fangni ZHANG [a*]
[a] *Department of Industrial and Manufacturing Systems Engineering,*
*The University of Hong Kong, Hong Kong SAR, China*
**Email: gongzw@connect.hku.hk; zzyzhang@connect.hku.hk; fnzhang@hku.hk (Corresponding author)*

This study considers an urban transportation system with ground transport service and urban air mobility (UAM) service, and investigates the UAM operations (network structures, frequency), the user choices and system performance of the air-ground joint transportation network. This study examines an urban transport system comprising an urban ground (UG) network and an urban air (UA) network. The UG network is partitioned into regions with well-defined Macroscopic Fundamental Diagram (MFD). The UA network consists of ground vertiports and UAM lines in the air. Commuters can use either the UG network directly or the UA network for part of their journey. We consider different demand scenarios, i.e., exogenous given demand and endogenous elastic demand. We investigate the impact of UAM operations on UG network congestion and system equilibrium under different demand scenarios. This study is the first in the literature that focuses on the operations and system performance of the combined air-ground urban transport network, which gives insights into UAM operations and the regulation of future city traffic. This study further extends the MFD-based traffic models with a two-level network, which includes an UA network and an UG network.

Keywords: Urban air mobility, Urban transportation system, Network equilibrium, MFD

**OBVIATING EXPLICIT MATRIX MANIPULATION FOR EXACT GRADIENT EVALUATION OF MATHEMATICAL PROGRAMS WITH EQUILIBRIUM CONSTRAINTS**

A. Heqing TAN [a, b*], B. Xiangdong XU [a*] and C. Anthony CHEN [b*]

[a] *Key Laboratory of Road and Traffic Engineering of the Ministry of Education, Tongji University, Shanghai, China*

[b] *Department of Civil and Environment Engineering, The Hong Kong Polytechnic University, Hong Kong, China*

[*] *Email: tanheqing@foxmail.com (Corresponding author)*

Mathematical programs with equilibrium constraints (MPECs) are an important class of problems with numerous applications in transportation. The gradient of MPECs contains valuable information that benefits algorithmic development and sensitivity analysis of traffic network equilibria. Existing approaches for gradient evaluation are computationally burdensome (if not prohibitive), requiring the explicit manipulation of matrices whose order scales linearly with the number of origin−destination pairs. To obviate these cumbersome operations, we develop an exact gradient evaluation approach that only needs to solve a quadratic program (QP) with equality constraints. We show that the QP has a comparable structure to standard traffic assignment problems, enabling fast gradient evaluation. The constrained QP is further reformulated as an unconstrained one to facilitate the development of efficient algorithms. Numerical results demonstrate the correctness of the developed approach on a small network and indicate: (1) compared with the benchmark, the QP approach can be up to 6 times faster while reducing the occupied memory by over one order of magnitude on medium-size instances; and (2) it successfully addresses large-scale instances that the benchmark cannot manage.

Keywords: Mathematical program with equilibrium constraints, Gradient evaluation, Quadratic programming

# HOW DOES THE LARGE LANGUAGE MODEL DECIDE TO SAVE PEDESTRIANS OR PASSENGERS? EVALUATION OF ETHICAL DILEMMAS IN CHATGPT-BASED DECISION-MAKING OF AUTONOMOUS VEHICLES

A. Zixuan XU [a], B. Neha SENGAR [a] and C. Tiantian CHEN [a*]
[a] *Cho Chun Shik Graduate School of Mobility,*
*Korea Advanced Institute of Science and Technology (KAIST), Daejeon, South Korea*
[*] *Email: nicole.chen@kaist.ac.kr (Corresponding author)*

Large Language Models (LLMs) have attracted global attention for their capabilities in knowledge acquisition and human-like reasoning. Although LLMs have demonstrated feasibility in performing autonomous driving tasks in simulated and real-world environments, questions remain regarding their safety and ethical decision-making. To address this, we propose a novel framework for evaluating and interpreting the ethical decision-making mechanism of LLM-driven autonomous vehicles. Our study investigates the ethical dilemma of whether to prioritize saving pedestrians or passengers, inspired by the Moral Machine Experiment. We used a stated preference survey to include factors of group size, age, gender, probability of death, and pedestrian behaviour to create 13,122 choice scenarios (a full factorial design) to analyze responses from advanced LLMs, including the GPT-4 series models from OpenAI and Mistral-Large from Mistral AI. Our findings reveal significant differences in the decision-making process and preferences for saving road users among these LLMs. Using a binary logit model to interpret GPT-4's decisions, we found that the estimated number of deaths, age, and gender significantly affect the model's choices. The decision tree method was also applied to analyze LLMs' decision-making processes, uncovering potential ethical standards and conditions considered by the models. Lastly, we discuss the implications for user acceptance of AV ethics and the limitations of LLMs in this context. This study provides valuable insights into ethical considerations in AI systems and thus facilitates the responsible development of AI in autonomous vehicles.

Keywords: Large Language Models, Autonomous Vehicle, Moral Dilemmas, AI Ethics, Choice Experiments

## SESSION B1: Electric Vehicle Grid Integration

# UNDERSTANDING CONSUMERS' NON-COMPENSATORY AND HETEROGENEOUS PREFERENCES FOR ELECTRIC VEHICLES

A. Jinghai HUO [a], B. Eui-jin KIM [b] and C. Prateek BANSAL [a*]

[a] *Department of Civil and Environmental Engineering, National University of Singapore, Singapore*

[b] *Department of Transportation System Engineering, Ajou University, Republic of Korea*

[*] *Email: prateekb@nus.edu.sg (Corresponding author)*

Previous studies eliciting preferences for electric vehicles (EVs) assume the compensatory behavior of consumers. However, consumers might follow non-compensatory rules where EVs may become unattractive beyond certain attribute cutoffs. To investigate such non-compensatory and heterogeneous EV preferences, we estimate a latent class model with attribute cutoffs using the preferences of over 800 potential car buyers from Singapore. We identify early and late EV adopters and their behavior, underscoring the significance of our findings to expedite EV adoption at different stages. For instance, subsidizing electricity is effective for late adopters as, unlike early adopters, they value future operating cost savings of EVs at an annual discount rate of 6%. Additionally, increasing the availability of EV models from top-selling brands could effectively drive early EV adoption in Singapore because early adopters place a considerably high value on the availability of EV models from the preferred brands when it is below their cutoff.

Keywords: Electric vehicle, Attribute cutoffs, Stated preference, Non-compensatory

# NETWORK EQUILIBRIUM OF BATTERY ELECTRIC VEHICLES CONSIDERING DRIVERS' RESTING BEHAVIOR

A. Zhibin CHEN [a], B. Yanling DENG [a, b], C. Chi XIE [c], D. Chenghe GUAN [a, d]
and E. Tianlu PAN [e*]
[a] *Shanghai Key Laboratory of Urban Design and Urban Science,*
*NYU Shanghai, Shanghai, China*
[b] *Department of Civil and Urban Engineering, New York University,*
*New York, United States*
[c] *Key Road and Traffic Engineering Laboratory of Ministry of Education,*
*Tongji University, Shanghai, China*
[d] *Division of Arts and Science, NYU Shanghai, Shanghai, China*
[e] *Department of Networked Intelligence, Peng Cheng Laboratory, Shenzhen, China*
**Email: pantl@pcl.ac.cn (Corresponding author)*

Driving fatigue cost is a major component of drivers' travel costs in an intercity or regional network. The charging behavior of electric vehicle (EV) drivers, which is generally synchronized with resting behavior, can contribute to the mitigation of fatigue, especially after a prolonged driving period. Overlooking the impact of driving fatigue on the travel cost may overestimate the side effects of the charging behavior, and result in biased flow distribution. In this study, by considering fatigue as part of the travel cost, we make the first attempt to investigate the impact of EV drivers' charging and resting behaviors on their fatigue cost, and thus their travel plans. To this end, a novel network equilibrium modeling framework is developed to capture the interaction among EV drivers' travel plans, which specify the routing, recharging, and resting plans on a general network where charging stations and rest stops are deployed. EV drivers are assumed to determine travel plans to minimize their individual travel costs. The equilibrium model is then formulated as a variational inequality and transformed into a nonlinear optimization problem. An efficient solution algorithm integrating column generation and Benders decomposition approach is proposed to solve the problem. Numerical results validate that considering the impact of driving fatigue on the travel cost emphasizes the need for en-route charging in long-distance trips, and appreciably changes the network flow and charging demand distribution. Additionally, large-sized batteries and fast chargers may not necessarily reduce drivers' travel costs since charging behavior can be synchronized with drivers' resting behavior.

Keywords: Electric vehicle; Diving fatigue; Charging behavior; Resting behavior; Network equilibrium

# FLATTENING THE ELECTRICITY LOAD PROFILE WITH ELECTRIC VEHICLES CONSIDERING URBAN MOBILITY

A. Jiazu ZHOU [a*], B. Seanglidet YEAN [a], C. Tianyu DONG [a], D. Bu Sung LEE [b] and E. Markus SCHLÄPFER [c]

[a] *Singapore-ETH Centre, Future Cities Lab Global, 1 Create Way, 138602, Singapore*

[b] *Nanyang Technological University, School of Computer Science and Engineering, 50 Nanyang Avenue,639798, Singapore*

[c] *Columbia University, Department of Civil Engineering and Engineering Mechanics, New York, United States*

[*] *Email: jiazu.zhou@sec.ethz.ch (Corresponding author)*

The increasing adoption of EVs adds stress to grids due to the additional electricity demand for EV charging. Meanwhile, the massive deployment of solar PV could introduce grid stability challenges. These obstacles can, in turn, hinder the advancement of EV adoption by limiting the number and size of EV charging stations. To tackle the grid operational challenges posed by the deployment of EVs and PV systems, this study explores the potential of using EVs to support the power grid operation by flattening the load profile and reducing the peak load. Initially, we leverage GPS-based mobile data to analyse urban mobility patterns. The mobility patterns are utilized as the input to estimate spatial-temporal EV charging demand. Subsequently, we develop a strategy to control the EV (dis)charging to reduce the peak loads, considering individual EV mobility. Furthermore, the study examines the impacts of various vehicle-grid integration modes (including naïve charging, optimized unidirectional charging, and optimized bidirectional charging) on grid performance. Our findings indicate that the naïve charging strategy could increase the peak load by approximately 10% if all internal combustion engine (ICE) vehicles are replaced by EVs. Our analysis also reveals that optimized unidirectional charging strategies can completely prevent any increase in peak load. While optimized bidirectional charging strategies not only flatten the load profile but also achieve a 5% reduction in peak load. Moreover, we find that the optimized charging strategies can significantly reduce the reliance on rapid-response fossil-fuel power plants and may even facilitate the shutdown of existing fossil-fuel infrastructure.

Keywords: Electric vehicle, Human mobility, Big data

# MULTI-SERVICE ELECTRIC FLEET MANAGEMENT FOR RIDES, PARCEL DELIVERIES, AND VEHICLE-TO-GRID SERVICES

A. Qingying HE [a*] and B. Wei LIU [a*]
[a] *Department of Aeronautical and Aviation Engineering*
*The Hong Kong Polytechnic University, Hong Kong, China*
[*] *Email: qingyinghe97@gmail.com; wei.w.liu@polyu.edu.hk (Corresponding author)*

In this paper, we propose a dynamic platform for managing electric vehicles (EVs) across passenger transport, parcel delivery, and vehicle-to-grid (V2G) services. The platform considers varying spatial and temporal demand patterns with the aim of enhancing vehicle utilization, platform profitability, and overall service quality. To solve the dynamic problem, it is divided into many small and continuous static multi-service ride-hailing sharing instances with equal time intervals. Each instance is formulated as an arc-based mixed-integer linear programming (MILP) model for matching EVs to the requests collected in the last time interval or unmatched in previous time intervals and rescheduling the vehicle routes. To ease the computational burden, we further use the Dantzig-Wolfe method to decompose it into a master problem and a subproblem. Then a customized branch-and-price-and-cut exact algorithm is developed to solve the problem. This synergistic approach captures temporal dynamics and optimizes decision-making. Numerical experiments in the Guangdong-Hong Kong-Macau Greater Bay Area demonstrate the effectiveness and applicability of our proposed solution method.

Keywords: Dynamic ride-hailing optimization, Ride-sharing economic, Vehicle-to-grid services, Branch and price algorithm

# DETERMINING RESIDENTIAL CHARGING STATION PLACEMENT BY INTEGRATING TRAVEL BEHAVIOURS AND POWER GRID CAPACITY CONSTRAINTS

A. Qihui LI [a], B. Nan ZHAO [b] and C. Páraic CARROLL [c*]
[a] *School of Civil Engineering, University College Dublin, Ireland*
[b] *School of Engineering, Lancaster University, UK*
[c] *Faculty of Architecture, Building and Planning, University of Melbourne, Australia*
[*] *Email: paraic.carroll@unimelb.edu.au (Corresponding author)*

The increasing usage of electric vehicles poses a challenge to charging infrastructures. The provision of residential charging stations effectively promotes the uptake of electric vehicles. It remains valuable to examine the incorporation of travel behaviours and the capacity limitations of the power grid when determining the placement of residential charging stations. Based on the national household travel survey in Ireland, the study introduces a Monte Carlo simulation framework to estimate residential charging demand when considering people's travel behaviours including travel frequency and distance of different trip purposes. A multi-objective optimisation model is proposed to determine the optimal locations and sizes of residential charging stations by balancing the coverage of daily charging demand throughout the week, the distance of connection to the transformers, and the capacity of transformers. A case study of Dublin examines the proposed models across various electric vehicle penetration scenarios. The results illustrate the distribution of daily residential charging demands across 524 small areas within the study area. Furthermore, a total of 159 charging stations equipped with 1168 chargers have been planned. A total of 128 transformers have been chosen to supply power to the charging stations. The proposed charging station placement method has good viability and adaptability for uncertain EV penetration scenarios and has the potential to be applied to residential charging station placement in urban areas, benefiting EV promotion and the power grid upgrade.

Keywords: Electric vehicles, Charging demand, Travel behaviour, Residential EV charging

SESSION B2: Traffic Safety and Accident Modeling

# RELATING SIMULATED TRAFFIC CONFLICTS WITH TRAFFIC ACCIDENT RECORDS – FINDINGS FROM THE GOJO DORI SCENARIO IN KYOTO

A. Andreas KELER [a*], B. Daijiro MAEDA [b], C. Satoshi NAKAO [b]
and D. Jan-Dirk SCHMÖCKER [b]
[a] *JSPS International Research Fellow, Department of Urban Management, Kyoto University, Kyoto, Japan*
[b] *Department of Urban Management, Kyoto University, Kyoto, Japan*
**Email: andreas.keler@mytum.de (Corresponding author)*

The reduction of traffic accidents has been a significant concern globally, with similarities observed in the trajectories of accident reduction efforts in Japan and other developed countries such as Germany. Recent data from Japanese urban areas indicate a potential influence of the aging population on accident rates, while overall accident rates in developed nations seem to plateau annually. To better understand these dynamics, Hyden introduced the "Swedish Traffic Conflicts Technique" inspired by Heinrich's work on industrial accidents. This technique focuses on mapping conflicts and accidents within "severity zones". Additionally, Surrogate Safety Measures (SSMs) derived from trajectory data offer insights into potential accidents in traffic flow simulations. This study proposes a method to relate traffic conflicts extracted from traffic flow simulations to historical accident records in Kyoto, Japan. Using data preprocessing techniques, standardized accident records from the Kyoto Police are analysed alongside simulation outputs. The simulation network is created based on OpenStreetMap data and manually edited for accuracy. Surrogate safety measures such as time to collision are extracted and matched to accident records using various techniques. Initial results suggest similarities between simulated conflicts and actual accidents, particularly in specific areas such as road intersections. Further analysis aims to refine the simulation network and explore additional factors such as street furniture and visibility enhancements to improve safety. Future research will involve calibration of simulation networks and advanced data matching techniques to enhance the understanding of traffic accident dynamics.

Keywords: Surrogate Safety Measures (SSM), Traffic Accidents, Urban Digital Twin, Microscopic Traffic Flow Simulation

# ANALYSIS OF TRAFFIC ACCIDENTS CONSIDERING THE FIELD OF VIEW

A. Daijiro MAEDA [a*], B. Andreas KELER [b*], C. Satoshi NAKAO [a]
and D. Jan-Dirk SCHMÖCKER [a]
[a] *Department of Urban Management, Kyoto University, Kyoto, Japan*
[b] *JSPS International Research Fellow, Department of Urban Management, Kyoto University, Kyoto, Japan*
**Email: maeda.daijiro.24x@st.kyoto-u.ac.jp; andreas.keler@mytum.de*
*(Corresponding author)*

Road transportation plays an indispensable role in people's lives as it forms the backbone of regions and towns, shapes the environment and landscape, and supports daily life and economic activities. However, it also constantly carries the risk of traffic accidents, making it an ongoing social issue amidst the development of road transportation. While there has been a decreasing trend in the number of traffic accidents and fatalities in recent years, many accidents still occur, with over half of them happening at intersections or nearby. Past research on traffic accidents around intersections has predominantly focused on large-scale intersections, lacking sufficient analysis on small-scale intersections in residential areas due to data limitations. Therefore, in this study, we aggregated OpenData-based intersection representations for obtaining the number of corner cuts (so called "sumikiri" in Japan) via a computational-geometric approach for relating them to nearby-situated facilities and finding relationships between visibility characteristics and the number of traffic accidents, particularly focusing on small-scale intersections. The analysis revealed that while the number of corner cuts did not show a significant impact on the number of traffic accidents at large-scale intersections, they had a statistically significant negative impact on traffic accidents at medium to small-scale intersections. This implies that intersection size influences the impact of corner cuts (i.e., visibility) on traffic accident occurrence. The results of this study suggest a potential relationship between the corner cut and the occurrence of traffic accidents at medium to small-scale intersections, providing insights that could contribute to future traffic accident prevention strategies.

Keywords: Traffic Accidents, Regression Analysis, Spatial Analysis, Urban Infrastructure Design

# A CONTINUOUS BI-CRITERIA TRAFFIC ASSIGNMENT MODEL WITH SAFETY CONSIDERATION

A. Umer MANSOOR [a], B. Zhengyang LI [a], C. Guoyuan LI [b] and D. Anthony CHEN [a*]
[a] *Department of Civil and Environmental Engineering,*
*The Hong Kong Polytechnic University, China*
[b] *Guangdong Leatop Technology Investment Co., Ltd., Guangzhou, China*
[*] *Email: anthony.chen@polyu.edu.hk (Corresponding author)*

This study models the traveler's trade-off between travel time and travel safety (e.g., crash risk) based on their heterogeneous safety concerns. To examine the user heterogeneity regarding the trade-off between travel time and safety, travelers' value of safety (VoS) is modeled as a random variable following a continuous distribution. It refers to the amount of time a traveler is willing to exchange (i.e., travel at a lower speed) to reduce his/her crash risk. A continuous bicriteria traffic assignment model is adopted to determine the distribution of travelers aiming to minimize their generalized route cost, modeled as a linear combination of travel time and crash risk cost (CRC). In this approach, the boundaries of the random variable i.e., VoS for classifying travelers into equal choice groups (ECGs) are determined endogenously by the model. Using a small network, the effect of travelers' heterogeneous safety concerns on route choice behavior is explored.

Keywords: Value of Safety, time safety trade-off, heterogeneous risk preferences

# URBAN VISUAL CLUSTERS: IMAGE ANALYSIS OF GLOBAL ROAD TRANSPORT FATALITIES

A. Zhuangyuan FAN [a*] and B. Becky P.y. LOO [a*]
[a] *Department of Geography,*
*The University of Hong Kong, Hong Kong SAR, China*
[*] *Email: yuanzf@connect.hku.hk; bpyloo@hku.hk (Corresponding authors)*

Road crash is the world leading cause of mortality and disability. City planning and urban design are known to have close relationship with road transport injury. However, our understanding of how urban environment may encode the risk of road transport injury is limited. This study utilizes a convolutional neural network alongside a graph-based community detection method to analyze over 10 million street view images from 127 cities, spanning from less developed to highly developed nations. It categorizes urban streetscapes into two-level urban visual clusters based on their visual similarities. Then, it evaluates the relationship between these visual clusters, the characteristics identified within the street view images, and the prevalence of road transport injuries at various scales: neighborhood, and regional. The characteristics include presence of sidewalks, traffic signs, road area, vehicle density, and build-up density. This study underscores the rich information encoded in the urban visual appearances and unveils significant disparities in urban design principles across cities. These disparities reflect varying economic statuses, developmental histories, and cultural contexts, ultimately contributing to unequal road safety environments.

Keywords: road crash, street view image, computer vision

As at December 7, 2024

# HOW DOES SUBJECTIVE PERCEPTION OF STREETSCAPE AFFECT TRAFFIC CRASHES? A SPATIAL ANALYSIS FOR INTEGRATING SAFETY INTO STREET PLANNING

A. Yiping LIU [a], B. Tiantian CHEN [a*], C. Hyungchul CHUNG [b], D. Kitae JANG [a] and E. Pengpeng XU [c, d]

[a] *Cho Chun Shik Graduate School of Mobility,*
*Korea Advanced Institute of Science and Technology, Daejeon, South Korea*
[b] *Department of Urban Planning and Design, Xi'an Jiaotong-Liverpool University, Suzhou, China*
[c] *School of Civil Engineering and Transportation, South China University of Technology, Guangzhou, China*
[d] *Hunan Key Laboratory of Smart Roadway and Cooperative Vehicle-Infrastructure Systems,*
*Changsha University of Science & Technology, Changsha, Hunan, China*
[*] *Email: nicole.chen@kaist.ac.kr (Corresponding author)*

Objective factors of the built environment have been found to play a significant role in traffic crash counts. While limited research has evaluated how people's all-around subjective perception indicators of streetscape affect crash risks. On the other hand, in the urban planning field, people’s subjective perception of streetscape is a fine-grained evaluation approach for urban street quality, and the integration of traffic safety perspectives into street planning has received considerable attention. Our study aims to examine the association between people’s subjective perception of streetscape and the traffic crashes counts. Apart from this, this study intends to explore the spatial heterogeneity and distribution of this association to inform targeted safety prevention measures for key streets during the street planning process. The study focuses on the urban area of Daejeon in South Korea. Six perceptual indicators were adopted to reflect the street quality and people’s psychological state. A Bayesian multivariate spatial-varying coefficients model was introduced to simultaneously account for spatial random effect and the shared effect across various crash severity. Results indicated that four of six perceptual variables present significant associations with slight injury crash counts, and there is obvious spatial heterogeneity in their effect. Road segments exhibiting the strongest traffic safety effects from perceptual factors, combined with those with low performance on perceptual indicators, were identified as key areas for additional traffic safety-enhancing measures. Overall, the findings are expected to facilitate the safety-enhanced street planning project and contribute to a human-oriented city.

Keywords: Road safety, Crash frequency, Subjective perception, Streetscape, Spatial heterogeneity

## SESSION B3: Adaptive Traffic Signal Control

# COORDINATED TRAFFIC SIGNAL CONTROL THROUGH DEEP REINFORCEMENT LEARNING WITH FUNDAMENTAL TRAFFIC FLOW FEATURES

A. Yifan ZHAO [a*], B. Lubing LI [a*], C. Zhiyuan ZHOU [a], D. Chak Y. LO [a] and E. Hong K. LO [a*]

[a] *Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology, Hong Kong SAR, China*

**Email: ceyz@ust.hk; celubing@ust.hk; cehklo@ust.hk (Corresponding author)*

Adaptive traffic signal control holds significant potential for alleviating traffic congestion, particularly in scenarios characterized by uncertain demand patterns. Among the various methodologies, reinforcement learning has emerged as a predominant approach. Despite the extensive utilization of reinforcement learning in research, many studies oversimplify traffic states and disregard fundamental traffic flow theory in their simulations, thereby failing to fully exploit the potential of reinforcement learning. In our study, we propose a specialized Proximal Policy Optimization deep reinforcement learning model to optimize network-wide traffic signal control strategies. By employing realistic representations of traffic states and straightforward control methods, our approach aims to enhance the performance of network-wide junctions by reducing traffic delays. To capture both spatial and temporal traffic characteristics, we adopt the Cell Transmission Model (CTM) for simulation and optimization. For assessing the traffic state, we employ a fundamental and easily accessible states: detector occupancy which can be readily modelled in CTM. Based on this traffic states, we introduce cycle-based signal control methods that ensure signal coordination among multiple junctions in the network. We set a common cycle for all junctions to ensure the coordination between junctions. Each individual agent focuses on optimizing cycle-based green splits for each junction under stochastic demand conditions. To assess the effectiveness of our model, we conduct extensive testing across various traffic conditions in the Tung Chung area in Hong Kong comprising six coordinated signalized junctions.

Keywords: Adaptive traffic signal, Deep reinforcement learning, Proximal policy optimization, Junction coordination, Multi-agent

**BAYESIAN TRAFFIC STATE ESTIMATION FOR ADAPTIVE SIGNAL CONTROL**

A. Zhiyuan ZHOU [a*], B. Lubing LI [a*], C. Yifan ZHAO [a], D. Ka Fai NG [a]
and E. Hong K. LO [a*]
[a] *Department of Civil and Environmental Engineering,*
*The Hong Kong University of Science and Technology, Hong Kong SAR, China*
**Email: cezhouzy@ust.hk; celubing@ust.hk; cehklo@ust.hk (Corresponding author)*

Adaptive traffic signal control is an effective approach for urban traffic management. Despite the dedicated efforts of recent researchers in traffic control optimization, most existing algorithms have been primarily developed for small-scale networks. As the number of junctions increases, comprehending the network-wide prevailing traffic state becomes increasingly challenging. Additionally, determining the optimal coordinated traffic control strategies in large networks poses an additional layer of complexity. To tackle this issue, we adopt an unsupervised learning method to cluster various traffic states into distinct groups, each characterized by its representative features. By examining these features, we can acquire a comprehensive understanding of the network-wide traffic states. This understanding empowers us to develop optimal control strategies within each group, thereby promoting effective coordination of traffic control across the entire network. In this study, we define the sensor time occupancy as the indictor of network-wide traffic state. A Bayesian nonparametric clustering method is adopted to divide these states into several clusters, with each cluster representing a typical recurrent traffic pattern. Within each cluster, dimensionality reduction is conducted to select critical components. We explore the relationship between these critical components that have significant influence on traffic performance and develop a GA-based optimization algorithm to determine optimal adaptive signal plans for each critical traffic pattern. The objective is to minimize the expected delays of the whole network. A case study in Tung Chung network is conducted to elaborate the effectiveness of the proposed control methods and its stability under demand fluctuation.

Keywords: Bayesian nonparametrics, Traffic state estimation, Traffic signal control

# A GROUP-BASED ADAPTIVE EMERGENCY VEHICLE PRIORITY SIGNAL SYSTEM

A. Seulbin HONG [a], B. Jihye BYUN [a], C. Wai WONG [b] and D. Seunghyeon LEE [a*]

[d]*Department of Transportation Engineering, The University of Seoul, Republic of Korea*

[b]*Department of Civil and Natural Resources Engineering, University of Canterbury, New Zealand*

**Email: seunghyeonlee@uos.ac.kr (Corresponding author)*

We developed a group-based adaptive preemption traffic signals for emergency vehicles along with a signalized intersection. This system gives prioritized green signals for emergency vehicles to allow them to pass without unnecessary stops and then minimize the control delay of the overall traffic flow alongside signalized corridors. There are three primary challenges to develop an adaptive priority signal for emergency vehicles. First, we employ a mixed objective function to minimize the travel time of emergency vehicles and the total delay of the network. Second, a bi-level optimization scheme is constructed to efficiently solve nonlinear optimization problems in real-time under undersaturated traffic conditions. Third, the group-based method has a high degree of flexibility in updating the optimal signal plan in response to real-time predicted traffic information. The bi-level optimization algorithm of signal timings that maximizes reserved capacity and minimizes the control delay is implemented in a microscopic simulation platform, the Simulation of Urban MObility (SUMO), with Python language as API. These simulations provided valuable insights into the system's performance, demonstrating a significant reduction in delay times for both emergency and regular vehicles compared to conventional priority signal systems along with consecutive signalized intersections. In conclusion, this study not only offers a new perspective on the emergency vehicle priority signal system but also lays the groundwork for further exploration and development in this field.

Keywords: Group-based optimization, Emergency vehicles, Priority signal system, Mixed objective function, Control delay

# A DYNAMIC PROGRAMMING BASED FRAMEWORK FOR ADAPTIVE TRAFFIC SIGNAL CONTROL

A. Guoyu HUANG [a], B. Wei HUANG [a*] and C. Min HUANG [a]

[a] *School of Intelligent Systems Engineering,*

*Shenzhen Campus of Sun Yat-Sen University, Shenzhen 518107, China*

[*] *Email: huangwei5@mail.sysu.edu.cn (Corresponding author)*

Traffic signal control is deemed to be a cost-effective approach to alleviate traffic congestion. This paper proposes a dynamic programming (DP) framework for adaptive signal control at urban intersections. Taking account of various traffic conditions, two objective functions are designed to optimize signal timings, including queue length minimization and throughput maximization. In the DP formulation, the forward recursion calculates the cumulative objective function of control schemes by enumerating signal stages sequentially. The feasible region of the state variable and control variable are constrained by both the minimum and maximum green duration of signal phases. The backward recursion determines the optimal control schemes by leveraging the information of objective function. In order to better adapt to the real-time traffic arrivals, a rolling optimization procedure is designed. Finally, the proposed DP signal control framework is tested in a simulated intersection using SUMO. Experimental results verify that the proposed adaptive control method can reduce the average delay compared with the fixed method and the actuated method. Besides, suitably setting the parameters of rolling optimization can further enhance the control performance.

Keywords: traffic signal control, dynamic programming, rolling optimization

# INTEGRATING A TIME-DEPENDENT REACTIVE LOCAL SIGNAL CONTROL POLICY WITH QUEUE-BASED GREEN LIGHT OPTIMAL SPEED ADVISORY (Q-GLOSA) SYSTEMS

A. Dohyeon KIM [a], B. Sooncheon HWANG [a], C. Jihye BYUN [a], D. Dongmin LEE [a], E. Wai WONG [b] and F. Seunghyeon LEE [a*]

[a] *Department of Transportation Engineering, The University of Seoul, Republic of Korea*

[b] *Civil and Natural Resources Engineering, Faculty of Engineering, University of Canterbury, Christchurch, New Zealand*

[*] *Email: seunghyeonlee@uos.ac.kr (Corresponding author)*

We develop a novel actuated signal control strategy for consecutive signalized intersections in a V2X-connected environment. The proposed methodology comprises the traditional actuated signal control policy, the Green Light Optimal Speed Advisory (GLOSA), and a procedure for real-time queue length estimation. This study addresses three primary challenges. First, we introduce pass-or-wait algorithms to implement GLOSA within the actuated signal control policy to maximize operational efficiency along a signalized corridor. Second, we incorporate a dynamic method for estimating vehicular queues in GLOSA to consider actual traffic conditions, allowing for optimal speed suggestions to vehicles equipped with On-Board Units (OBUs) within the V2X communication range. Third, we propose a dynamic signal phase system that updates every hour based on the estimated queue lengths and collected traffic data. We evaluate the proposed methodological framework by comparing it to traditional fixed-time signal control, GLOSA, and a time-dependent actuated signal algorithm within an integrated simulation platform. This evaluation includes two conditions: OBU penetration rates and traffic congestion levels. The numerical results indicate that the proposed methodology outperforms traditional algorithms across diverse traffic conditions and penetration rate scenarios. The proposed approach paves the way for the application of GLOSA, which considers real-time queue lengths to enhance the performance of actuated signal control policies under various traffic and V2X communication conditions. Additionally, it establishes a foundation for a real-time queue length estimation method within the GLOSA algorithm, offering realistic optimal speed recommendations for vehicles approaching intersections.

Keywords: C-ITS, GLOSA algorithm, Queue length estimation, Traffic control, Time-dependent

SESSION B4: Data-Driven Ride-Hailing Optimization

# ENHANCING AUTONOMOUS MOBILITY ON DEMAND SYSTEMS: A HIERARCHICAL REPOSITIONING APPROACH INTEGRATING REGIONAL-LEVEL AND ROUTE-LEVEL DECISION

A. Taijie CHEN [a*], B. Jingyun LIU [b], C. Zhongyou Hu[c], D. Siyuan FENG [d*] and E. Jintao KE [a*]
[a] *Department of Civil Engineering, The University of Hong Kong, China*
[b] *Department of Electrical and Computer Engineering,*
*Carnegie Mellon University Silicon Valley, USA.*
[c] *Department of Mathematics, the University of Hong Kong, Hong Kong, China*
[d] *Department of Logistics and Maritime Studies, Hong Kong Polytechnic University, China.*
**Email: ctj21@connect.hku.hk;sfengag@connect.ust.hk;kejintao@hku.hk (Corresponding authors)*

Vehicle repositioning addresses the significant spatiotemporal imbalance between supply and demand. This has spurred research into developing effective repositioning algorithms. Regional-level methods direct drivers from one region to another using the shortest route, whereas do not ensure higher probabilities of picking up passengers. Route-level methods focus on local path selection, lacking a global perspective for empty vehicle repositioning decisions. To address these challenges, we introduce a hierarchical method that integrates regional-level and route-level repositioning decisions. At the regional level, our method uses reinforcement learning to guide the movement of empty vehicles, deciding whether to stay or move to a new area. At the route level, our method applies MCTS to determine the optimal routes within the targeted area, maximizing potential passenger pickups. Our extensive experiments in Manhattan verify the efficacy of our method, demonstrating significant improvements in key performance metrics.

Keywords: Autonomous Mobility-on-Demand systems; vehicle reposition; reinforcement learning; Monte Carlo Tree Search.

# GRAPH CONVOLUTIONAL NETWORKS BASED DYNAMIC TAXI ROUTE RECOMMENDATION

A. Youngryeong LEE [a,b], B. Juhyeon KWAK [a,b], C. Minje CHOI [a], D. Seungjae LEE [a*]
[a] *Department of Transportation Engineering, University of Seoul, Republic of Korea*
[c] *Department of Smart Cities, University of Seoul, Republic of Korea*
*Email: sjlee@uos.ac.kr*

This research builds a taxi demand forecasting model and based on this, designs an optimized cruising route recommendation system to assess the effectiveness of the proposed route recommendation algorithm. Developing a taxi routing recommendation system to minimize the distance traveled without passengers faces various challenges. Taxi cruising routes recommendation heavily rely on potential taxi demand, which varies over time, making accurate predictions difficult due to spatial-temporal correlations and dynamic traffic patterns. Moreover, not considering competition and cooperation among taxi drivers leads to an oversupply in popular boarding areas, causing excessive competition, extended vacant distances, and worsening traffic congestion. To address these issues, this research proposes a new approach that analyzes and models the interaction between overall benefit and individual gain in taxi drivers' route selection strategies. The proposed taxi routing recommendation system algorithm combines taxi trajectory data, smart card data, and real-time urban data with the LSTM-GCN (Long Short-Term Memory - Graph Convolutional Network) algorithm to predict short-term taxi demand and recommend the optimal cruising routes. Simulation results confirm that the proposed route recommendation algorithm significantly improves the reduction in empty taxi distances and average waiting times. The taxi cruising optimization model presented in this research not only enhances the efficiency of urban transportation but also has the potential to lead to substantive strategic changes in traffic management and environmental sustainability.

Keywords: long-short-term-memory-based graph convolutional network (LSTM-GCN), spatiotemporal correlations

# PREDICTING ELECTRIC BUS POWER CONSUMPTION CONSIDERING BUS ROUTE CHARACTERISTICS

A. Ara CHO [a, b], B. Minje CHOI [a], C. Sion KIM [a], D. Ilho JEONG [a] and E. Seungjae LEE [a*]
[a] *Department of Transportation Engineering, University of Seoul, Seoul, South Korea*
[b] *Department of Smart Cities, University of Seoul, Seoul, South Korea*
[*] *Email: sjlee@uos.ac.kr (Corresponding author)*

This study proposes strategies for predicting electric bus power consumption. The challenges involved in this task include building a fusion model that integrates diverse data sources and accounts for varying bus route characteristics. Existing research primarily focuses on the relationship between the bus's physical characteristics and power consumption, leading to the need for a more comprehensive approach that includes bus route characteristics like curvature, length, and station density. Therefore, this study considers both the characteristics of bus routes and driving patterns to predict power consumption with a specific focus on buses. We analyzed data from electric bus operations by classifying variables related to route characteristics as static information and driving pattern variables such as acceleration and speed recorded per second as dynamic information. To effectively apply these insights, we fused XGBoost for static information with Long Short-Term Memory (LSTM) networks for dynamic information. This approach has the potential to clearly identify and address the specific energy consumption patterns of electric buses, leading to more efficient and sustainable urban transportation systems.

Keywords: Electric Bus, Power Consumption, Bus Route Characteristic, XGBoost, LSTM

# PRIVACY-PRESERVING PERSONALIZED REVENUE MANAGEMENT OF RIDE-HAILING PLATFORM

A. Bing SONG [a] and B. Sisi JIAN [a*]

[a] *Department of Civil and Environmental Engineering,*
*The Hong Kong University of Science and Technology, Hong Kong SAR, China*
[*] *Email: cesjian@ust.hk (Corresponding author)*

This research addresses the growing concern of balancing personalized services with data privacy in the ride hailing industry. While personalized pricing and matching strategies, fueled by travelers' personal data, can optimize platform revenue, they also expose users to significant privacy risks. The correlation between personalized pricing, waiting times, and personal information might be exploited by third-party agents to infer sensitive individual attributes, resulting in potential economic losses for the platform and severe consequences for travelers, including compromised privacy and potential discrimination. Existing privacy protection methods often fall short in providing robust and quantifiable guarantees. To overcome these limitations, this study introduces a privacy-preserving approach for personalized pricing and matching within ride-hailing platforms. The proposed approach leverages the bounded Laplace mechanism and parallel composition to inject noise into the order price and waiting time feedback provided to travelers. This study rigorously demonstrates that the proposed approach satisfies differential privacy. Furthermore, the proposed approach outperforms other classic privacy-preserving methods in terms of platform revenue. This superior performance is validated through extensive numerical experiments using realistic ride-hailing data.

Keywords: Privacy-preserving, Personalized pricing, Ride-hailing, Differential privacy

# MODELLING THE RIDE-SOURCING MARKET UNDER BROADCASTING MATCHING MODE

A. Ce WANG [a*], B. Kaihang ZHANG [a] and C. Jintao KE [a]
[a] *Department of Civil Engineering, the University of Hong Kong, Hong Kong, China*
[*] *Email: u3009647@connect.hku.hk (Corresponding author)*

Ride-sourcing, a novel mode of transportation, has significantly evolved in recent years, reshaping our travel habits. It operates on an on-demand basis, with ride-sourcing platforms facilitating a seamless connection between customers and drivers. The core of this service lies in the matching process, which operates in two primary modes - dispatching and broadcasting. In the dispatching mode, the platform assigns customers to drivers, who don't have the liberty to choose their orders. Conversely, the broadcasting mode enables the platform to share order information with drivers, granting them the choice to accept or reject the order. While considerable research has delved into the dispatching mode, the broadcasting mode has attracted limited study, and even fewer have theoretically examined the ride-sourcing market using a mathematical model. This research aims to fill this gap by proposing an analytical model to characterize and scrutinize the monopolistic ride-sourcing market that employs the broadcasting matching mode, under batch matching mechanisms. It examines the influence of operational strategies and market characteristics on factors like customer waiting time, platform profit, and social welfare. The study's findings, derived from theoretical analytics and numerical experiments, indicate that customers who offer a higher fare under the broadcasting matching mode may encounter longer waiting times. In addition, if drivers become more selective, it could potentially reduce customer waiting times. Moreover, it was discovered that under optimal conditions for monopoly and social welfare, the ideal matching time interval is almost zero, and the optimal matching radius is equivalent to the maximum distance drivers are willing to cover to accept an order.

Keywords: Broadcasting, batch matching, Optimization, shared mobility

SESSION B5: Elderly Transportation and Mobility Behavior

# ANALYZING SENIORS’ UNREALIZED LEISURE NEEDS CONSIDERING INTERACTIVE EFFECTS OF THEIR CLINIC VISITS: A COPULA-BASED APPROACH

A. Jianbiao WANG [a*] and B. Tomio MIWA [b]

[a] *Department of Civil and Environmental Engineering, Nagoya University, Nagoya, Japan*

[b] *Institute of Innovation for Future Society, Nagoya University, Nagoya 464-8603, Japan*

**Email: wang.jianbiao98@gmail.com (Corresponding author)*

Daily leisure activities significantly impact seniors' quality of life. But many seniors face challenges in fully satisfying their leisure needs due to decreased mobility. This study investigated their unrealized leisure needs. Furthermore, seniors are featured by declined health and frequent clinic visits, which may limit their spare time and result in unrealized leisure activities. On the other hand, the higher unrealized leisure needs indicate a higher probability of being socially excluded, which may trigger psychological problems and clinic visits. Hence, it is necessary to accommodate the intercorrelated relationship between clinic visits and unrealized leisure needs. In this study, a survey was conducted in central Japan, collecting information from 1409 seniors for analysis. The copula-based bivariate count model was adopted to investigate the influential factors of unrealized leisure needs and clinic visits, as well as capture the interactive correlation between them. Results confirm that clinic visits could impede seniors' leisure engagement. Finally, policy implications are proposed to reduce seniors’ unrealized leisure needs.

Keywords: life satisfaction; unrealized leisure needs; clinic visits; copula-based model

As at December 7, 2024

# EXPLORING PARA-TRANSIT CHOICE BEHAVIOUR IN PERI-URBAN AREAS OF KOLKATA, INDIA

A. PRITAM SAHA [a*], B. SUCHISMITA NAYAK [b] and C. SOUMEN MITRA [b]
*[a] Department of Civil Engineering, Indian Institute of Engineering Science and Technology, Shibpur, India*
*[b] Department of Architecture and Planning, Indian Institute of Engineering Science and Technology, Shibpur, India*
**Email: pritam@civil.iiests.ac.in (Corresponding author)*

Peri-urban areas of many metropolises in the developing world have experienced unplanned growth due to rapid urbanization, complicated land use dynamics and inefficient transport infrastructure. The inadequacy of mass transit services in such areas forces many commuters to rely heavily on paratransit. This places additional strain on existing infrastructure. This paper aims to explore the commuter choice behaviour of paratransit modes while striving to identify a balanced state of system efficiency that harmonizes safety and mobility. A study has been conducted in selected peri-urban areas of Kolkata Metropolis, India. A structured questionnaire was designed for an opinion survey aimed at gathering insights into the socio-economic and mode-specific attributes of commuters. Data collection was conducted using a dual approach, encompassing both online and offline methods. The result indicates that there is a positive correlation between family income and paratransit choices. It also reveals that the proportion of paratransit users is very high among school children and senior citizens compared to the working population. More females use paratransit than males. The study explains that short trip distances due to mixed land use are a pivot for paratransit with multiple transfers since mass transit is almost impossible here with limited road capacity. It also highlights that paratransit has become a backbone of local transportation for non-work trips. Finally, the study emphasizes the urgent need to propose strategies for extending paratransit route lengths, minimizing the number of transfers for work-related trips, and implementing staggered timings for paratransit operations.

Keywords: Urban mobility, peri-urban areas, transport preferences, para-transit

# UNDERSTANDING POPULATION BEHAVIORAL DYNAMICS PATTERN AT URBAN TRANSPORTATION HUB: INSIGHTS FROM AGGREGATED MOBILE PHONE LOCATION DATA IN KYOTO, JAPAN

A. Alvin NOVIANSYAH [a*], B. Nobuhiro UNO [a], C. Ryoji MATSUNAKA [a] and D. Tomoki NISHIGAKI [a]

[a] *Department of Urban Management, Kyoto University, Japan*

**Email: noviansyah.alvin.35r@st.kyoto-u.ac.jp (Corresponding author)*

This study investigates the complex characteristics of populations behavioral pattern at a major urban transportation hub at Kyoto city, Japan, by scouring population data from Mobile Spatial Statistics™, which aggregates population information across spatial and temporal dimensions. Leveraging a rich dataset encompassing spatial and temporal dimensions, the behavior that connects between human activities and the transportation hub is expected to establish a pattern in which understanding it would benefit the urban and transportation planning field. Utilizing tensor decomposition, extracted activity patterns that incorporate various characteristics are expected to create patterns that this research aims to utilize to understand the nuanced behavioral dynamics of commuters and visitors. The insights gained from this analysis provide valuable information for urban and transportation planning, as well as development and management of the urban's transportation hubs. Understanding the demographics and movement patterns within such a significant urban node offers a deeper comprehension of human mobility and its interactions with the built environment, thereby informing strategies for better urban management and infrastructure development.

Keywords: Tensor Decomposition, Activity Pattern, Population Dynamics, Mobile Spatial Statistics™

# DECODING THE SPATIAL EFFECTS OF WALKABILITY ON WALKING BEHAVIOR AMONG OLDER ADULTS BY INTEGRATING BIG DATA AND SMALL DATA

A. Xuan HE [a*] and B. Sylvia Y. HE [a*]
[a] *Department of Geography and Resource Management,*
*The Chinese University of Hong Kong, Shatin, N.T., Hong Kong*
**Email: xuanhe@link.cuhk.edu.hk; sylviahe@cuhk.edu.hk (Corresponding author)*

A walkable environment promotes older adults' walking. However, there are few studies that incorporate big and small data to examine the relationship between walkability and older adults' walking behaviors. Using Shenzhen (China) as the study area, this study explores the effects of walkability on senior walking behaviors by integrating big data and small data. The walkability framework is developed in terms of four pedestrian needs: safety, convenience, continuity, and attractiveness. The walkability elements are extracted from street view images and diverse sources of open data. We quantify the importance of walkability elements from 459 questionnaires across the city as weights to calculate elderly walkability scores. More than 27 million senior walking trips are identified from 6 months of mobile phone data in 2021. We used geographically weighted Poisson regression model to examine the spatial effects of walkability on senior walking trips. Results show that the most important pedestrian need for seniors is safety, followed by attractiveness, convenience, and continuity. Areas with high elderly walkability scores are largely in urban areas and suburban sub-centers. Walkability plays a strong positive role in senior walking trips in the inner suburbs. Based on the findings, we tailor intervention strategies to foster age-friendly walking environments.

Keywords: Walking behavior; Walkability; Mobile phone data; Street view image; Deep learning.

# AN INTEGRATED OPTIMIZATION MODEL FOR ELDERLY-FRIENDLY PUBLIC BUS PLANNING

A. J. XIE [a*], B. F. FU [b], C. S. ZHAN [c], D. M. CAI [d] and E. S.C. WONG [e]

[a] *Shenzhen Campus of Sun Yat-sen University & Guangdong Provincial Key Laboratory of Intelligent Transportation System, School of Intelligent Systems Engineering, Sun Yat-sen University, China*

[b] *School of Intelligent Systems Engineering, Sun Yat-sen University, China*

[c] *School of Automotive and Transportation Engineering, Hefei University of Technology, Hefei, China*

[d] *School of Intelligent Systems Engineering, Sun Yat-sen University, China*

[e] *Department of Civil Engineering, The University of Hong Kong, Hong Kong, China*

**Email: xiejm28@mail.sysu.edu.cn (Corresponding author)*

The aging population now poses a significant challenge, making it crucial to enhance the quality of life for elderly individuals. One way to achieve this is by developing an elderly-friendly public bus system, as older adults primarily rely on buses for intracity transportation. Key factors that influence an elderly person's decision to use public buses include the convenience of accessing the bus system, the duration of the trip, and the ease of transferring between routes. To address these concerns, this study introduces an integrated optimization model for elderly-friendly public bus planning that takes into account bus stop allocation and route design. The model aims to maximize bus stop accessibility while minimizing travel time and the number of transfers, while considering bus resource constraints, passenger dynamic path choices, and the specific needs of elderly individuals. For optimal planning results, the model should be adaptable to various bus networks. However, this adaptability increases computational complexity. To mitigate this issue, the study recommends dividing the region serviced by the bus network into smaller zones, and implementing a bi-level model. In the first level, zone-level bus routes and the number of bus stops within each zone are determined. In the second level, road-level bus routes and the precise allocation of bus stops are decided. To further enhance the efficiency of model solving, a column generation algorithm is employed. A real-world example is provided to test the efficacy of both the model and the algorithm.

Keywords: bus route design, bus stop allocation, elderly-friendly service, bi-level modeling

SESSION B6: Air Transport Operations and Management

**COMPETITIVE OR COMPLEMENTARY RELATIONS AMONG PRIMARY AIRPORTS IN JAPAN FROM A HUB PERFORMANCE PERSPECTIVE**

A. H. MATSUMOTO [a*] and B. K. DOMAE [a]
[a] *School of Policy Studies, Kwansei Gakuin University, Japan*
**Email: h.matsumoto@kwansei.ac.jp (Corresponding author)*

The main purpose of this paper is to assess and compare the competitive or complementary relations among four primary airports in Japan (Tokyo Int'l (Haneda), Narita Int'l, Kansai Int'l and Chubu Centrair Int'l). After classifying air passenger traffic movements into four types (direct, beyond, behind and bridge), the paper first identifies the accuracy of the Official Airline Guide (OAG) data by comparing them with the official statistics of the Japanese government. Next, the paper explores the air passenger traffic movements at these four primary airports in 2019, employing the data estimated by the OAG Traffic Analyzer. The results demonstrate that local passengers occupy the majority at these four primary airports and that Tokyo Int'l (Haneda) and Narita Int'l play a larger role as transfer airports of Kansai Int'l and Chubu Centrair Int'l. The paper sheds light on net traffic flows to refine our understanding of the competitive or complementary relations among these four primary airports in Japan from a hub performance perspective, which is one of the key contributions of this paper.

Keywords: Air traffic types; Gross traffic flows; Net traffic flows; Competitive or complementary relations and Japanese primary airports

As at December 7, 2024

# MODELING A RISK-AVERSE AIR FREIGHT FORWARDER'S CAPACITY MANAGEMENT UNDER THE POST-PANDEMIC DEMAND AND FLIGHT TIME UNCERTAINTIES

A. Kannapha AMARUCHKUL [a] and Sarawut JANSUWAN [a*]

[a] *Graduate School of Applied Statistics, National Institute of Development Administration (NIDA), Bangkok, Thailand*

** Email: sarawut@as.nida.ac.th (Corresponding author)*

Despite experiencing a significant decline in 2020 due to the global COVID-19 pandemic, air cargo demand has demonstrated impressive resilience, rebounding faster than passenger demand. Air cargo contributed to global trade recovery by facilitating the movement of goods and materials across borders. The long-term block space agreement ensures advantageous freight rates and reserved capacity on direct flights, which is essential for time-sensitive air shipments. Exceeding the daily allotment prompts the forwarder to buy costlier space from the spot market or opt for indirect flights with plausibly extended transit times. This study develops a two-stage stochastic programming model for both short- and long-term capacity management faced by risk-averse freight forwarders. In the first stage, the forwarder establishes long-term allotments in uncertain demand. Each block space agreement (BSA) comes with a distinct freight rate and a minimum chargeable weight requirement. In the second stage, once the daily demand is realized, the forwarder makes short-term decisions regarding cargo allocation between BSA and non-BSA flights while the flight travel times are still uncertain. The model minimizes the conditional value at risk (CVaR) of the total cost, including the freight, the inventory, and the travel time costs charged on air freight forwarders. A case study compares the suggested alternative to the present technique using historical demand data from one of Thailand's leading air freight forwarders. The proposed strategy results in substantial cost reductions for the top five destinations. The policy for the risk-neutral forwarder is being compared to the policy for the risk-averse forwarder.

Keywords: Air Freight Capacity Management, Risk-Averse, Capacity Allotment, Air Freight Forwarder, Conditional Value at Risk (CVaR)

# RESOURCE ALLOCATION IN AIR-RAIL-INTEGRATED CO-MODALITY UNDER BOTH DEMAND AND SUPPLY UNCERTAINTIES

A. Xinyi ZHU [a] and B. Wei LIU [a*]
[a] *Department of Aeronautical and Aviation Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
[*] *Email: wei.w.liu@polyu.edu.hk (Corresponding author)*

The advent of Cross-Border E-Commerce has expanded the scope of co-modality mode, a system known for its substantial benefits in efficiency and cost-effectiveness. Air-rail-integrated co-modality emerges as a promising solution to leverage under-utilized capacity for cargo delivery. In this paper, we study the resource allocation problems of this novel co-modality. We dynamically match existing resource, i.e., excess capacity of High-speed railway (HSR) trains and passenger aircrafts to randomly arriving cargo demand. To ensure efficiency and flexibility on the operational level, the air-rail co-modality operator needs to consider supply-demand uncertainty. To formulate this problem, a two-stage stochastic programming model is proposed to minimize the total costs associated with transportation, holding, transshipment, delays, and ad-hoc options. A rolling horizon framework is introduced to make sequential decisions through a look-ahead mechanism, incorporating the departure time forecasting. The Sample Average Approximation (SAA) algorithm is applied in each period. Our model is benchmarked with the one that optimizes the resource allocation without departure time forecasting. We use test instances generated based on the HSR trains arriving at the Hong Kong West Kowloon Station and the passenger aircrafts departing from Hong Kong Airport data for one day. The computational studies and sensitivity analysis are conducted to show (i) the benefits of the air-rail-integrated co-modality, (ii) the sensitivity analysis on uncertainty level. Numerical results show that introducing co-modality results in an average cost-saving of 8.27% and that 26.67% of cargo orders utilize co-modality mode.

Keywords: air-rail-integrated co-modality, mixed-integer stochastic programming, Sample Average Approximation, real-time algorithm

# THE IMPACTS OF EXCHANGE RATE FLUCTUATIONS ON THE INTERNATIONAL AIR PASSENGER TRANSPORT MARKET: THE CASE OF THE CHINESE INTERNATIONAL AIRLINE MARKET

A. Yulu HE [a], B. Wenliang MA [b*], C. Keke FAN [c] and D. Kun WANG [a]
[a] *Department of Industrial and Systems Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
[b] *Capital University of Economics and Business, Beijing, China*
[c] *Beijing Volcano Engine Technology Co., Beijing, China*
[*] *Email: wenliangma@cueb.edu.cn (Corresponding author)*

The fluctuations of foreign exchange rate can affect the international air transport markets through both the demand and supply sides. On one hand, exchange rate variations can affect the passengers' overseas purchasing power so as to influence people's international travel decisions (i.e., demand side). On the other hand, as airlines normally pay foreign currency (i.e., the US dollar) for capital/operation costs, the foreign exchanges rates also affect the supply side. Leveraging on the monthly data from 2017 to September 2019 on international routes operated by Chinese airlines, this study conducts an empirical investigation trying to disentangle and quantify the impacts of foreign exchanges on both demand and supply sides of international air travel market. To address the potential endogeneity caused by those unobservable confounding factors that jointly affect the exchange rates and international air travel market, this paper innovatively selects the international routes linking mainland China to five regions that peg their exchange rates to the US dollar, such that the exchange rate fluctuations are exogenous on these routes. The structural econometric equations are estimated for these international routes to disentangle the impacts of exchange rate fluctuations on both demand and supply sides. Specifically, the exchange rate fluctuations are categorized into three types: severe depreciation, severe appreciation, and moderate bidirectional fluctuations. Our empirical findings indicate that the moderate bidirectional exchange rate fluctuations influence international passengers' air travel demand. On the other hand, severe depreciation and severe appreciation significantly impact airlines' pricing decisions on routes, with symmetrical effects in both directions.

Keywords: international aviation markets, exchange rate fluctuations, air passenger demand, airline cost

# EXPLORING PASSENGER AIRLINE NETWORKS BEYOND HUB-AND-SPOKE AND POINT-TO-POINT: OPPORTUNITIES AND CHALLENGES

A. Richard KLOPHAUS [a*]
[a] *Competence Center Aviation Management (CCAM),*
*Worms University of Applied Sciences, Germany*
**Email: klophaus@hs-worms.de (Corresponding author)*

Airline networks are a key aspect of any airline business model and can be described in terms of their spatial and temporal configuration. This paper seeks to broaden the traditional dichotomous perspective of hub-and-spoke (HS) and point-to-point (PP) networks by exploring mesh networks and milk-runs as additional network topologies. A Milk-run is a routing system where an aircraft serves multiple intermediate stops along a single route. A mesh network can be viewed as a middle ground between PP and HS networks. It combines a set of point-to-point routes with permissible geographical detour factors and connection time window thresholds for passenger transfers allowing a carrier to market online connections, i.e., indirect connections within the carrier's own network. The paper systematically compares the commonalities and differences among the examined network topologies and provides industry cases for each network type. While milk-runs and mesh networks have not yet received much attention in the academic literature, they appear to be viable managerial options to optimize network configurations for airlines beyond point-to-point operations and hub-and-spoke networks.

Keywords: Airline management, network planning, mesh network, milk-run

## SESSION C1: Airport Operations and Capacity Optimization

# CAPACITY ALLOCATION OF PASSENGER AIRLINES FOR AIR CARGO TRANSPORTATION

A. Yufan ZUO [a] and B. Wei LIU [a*]

[a] *Department of Aeronautical and Aviation Engineering,*
*The Hong Kong Polytechnic University, Hong Kong, China*

[*] *Email: wei.w.liu@polyu.edu.hk (Corresponding author)*

We develop a two-stage stochastic program designed to optimize the management of unused passenger airline capacity for air cargo transportation. Both demand uncertainty and capacity supply fluctuation are considered in our studied problem. The program is structured into two stages: the first stage introduces a mid-term capacity reservation scheme and the second stage focuses on the allocation of cargo to flights in the short term. Under the consideration that the unused capacity can be either sold or used for cargo transportation, optimization in the first stage aims to minimize the total cost in the mid term period and maximize the potential benefits from selling capacity. Given the mid-term capacity reservation schemes decided in the first stage, the second stage optimizes the short-term cargo-to-flight allocation to minimize the total operating cost in the short-term period. We employ the Sample Average Approximation method for problem decomposition and utilize the Progressive Hedging algorithm to optimize the first-stage variables. To get high-quality second-stage solutions under various sample scenarios, we compare several heuristic algorithms against lower bounds derived from a Lagrangian relaxation model. Based on the generated results, we choose the one with the best performance regarding the gap with the lower bound and time expense and apply it in the calculation of second-stage operating costs. Through extensive numerical experiments conducted on both medium and large-scale instances, we demonstrate the effectiveness of our proposed framework. Our framework successfully identified high-quality feasible solutions, with the objective value showing less than 5\% fluctuation (when compared to the results from 200 sample scenarios) using 20 sample scenarios, and less than 1\% fluctuation with 100 sample scenarios.

Keywords: Air cargo transportation, Unused airline capacity, Demand uncertainty, Airline capacity uncertainty, Two-stage stochastic program

# JOINT OPTIMIZATION OF AIRPORT SLOT ALLOCATION AND GATE ASSIGNMENT: A STOCHASTIC INTEGER PROGRAMMING APPROACH

A. Xuanji LONG [a] and B. Wei LIU [a*]
[a] *Department of Aeronautical and Aviation Engineering,*
*The Hong Kong Polytechnic University, Kowloon, Hong Kong*
[*] *Email: wei.w.liu@polyu.edu.hk (Corresponding author)*

This paper presents a novel framework for solving the joint optimization problem of strategic schedule slot allocation and operational gate assignment for a single airport with capacity constraints, taking into account operational uncertainty. Despite their interdependence, these two problems are typically treated in isolation. In this paper, we study the problem using a two-stage stochastic integer programming model. To more accurately reflect the operational reality of an airport, the gate assignment problem is formulated as an online problem, where the uncertainty information is updated on a rolling basis as time progresses. The model is solved efficiently using a Benders-based decomposition algorithm and rolling horizon approach to solve the subproblems. Numerical experiments are conducted in various realistic scenarios based on real historical flight data from Shanghai Pudong Airport. The experimental results demonstrate that the proposed approach is highly effective in solving large-scale instances, indicating its potential applicability in the field of airport scheduling and operations.

Keywords: airport slot scheduling, gate assignment, stochastic integer programming, benders decomposition, rolling horizon

# AIRPORT'S OPTIMAL DECISIONS CONSIDERING NON-AERONAUTICAL BUSINESS, TERMINAL CAPACITY AND DIFFERENT REGULATORY REGIMES

A. Yue HUAI [a], B. Enoch LEE [b*], C. Hong K. LO [a] and D. Anming ZHANG [c]

[a] *Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, China*

[b] *Department of Logistics and Maritime Studies, The Hong Kong Polytechnic University, Kowloon, Hong Kong, China*

[c] *Sauder School of Business, University of British Columbia, 2053 Main Mall, Vancouver, BC, Canada*

[*] *Email: enoch.lee@polyu.edu.hk (Corresponding author)*

This study explores the optimal decisions of airports on charge, capacity, and suggested arrival time at the airport to passengers under various regulatory regimes (e.g., single- or dual-till regulation). By considering both aeronautical and non-aeronautical business and further incorporating the non-linear relationship between queuing time in the check-in zone and shopping time in the retail zone, we find that unlike runway capacity expansion where single-till regulation leads to underinvestment (as compared to the unregulated case), terminal capacity expansion is contingent upon traffic volumes. Under higher traffic volumes, terminal capacity expansion becomes less efficient in reducing the terminal congestion delay, thereby reducing passengers' shopping time and concession revenue. As the revenue loss is disregarded under single-till regulation, airports would overinvest in terminal capacity under higher traffic volumes, which reverses the underinvestment trend under lower traffic volumes. Also, single-till regulation results in a later arrival time suggested to passengers, for which the excess concession revenue from an earlier arrival time is overlooked. By contrast, dual-till regulation tends to attract more passengers to the airport by reducing terminal and runway delays, therefore leading to lower airport charge, shorter terminal time and higher capacity. The increased ridership and enhanced utility enhances overall social welfare.

Keywords: Non-aeronautical business, Terminal capacity expansion, Suggested arrival time, Single- vs. dual-till regulation

As at December 7, 2024

# PREDICTION OF LANDING TIME DELAYS WITH MULTIPLE APPROACHING ROUTES TO AN AIRPORT

A. Yuxin WANG [a], B. Feihong YU [a], C. Man Fung HO [a], D. Bo PENG [a],
E. Qinhan WEN [a], F. Qiaowen TAN [a], G. Tat Shing CHOI [b] and H. K. Y. Michael WONG [a]
[a] *Department of Physics, The Hong Kong University of Science and Technology, China*
[b] *Department of Science and Environmental Studies, The Education University of Hong Kong, China*
[*]*Email: ywangsl@connect.ust.hk; fyuai@connect.ust.hk; mfho@connect.ust.hk; bpengaj@connect.ust.hk; qwenad@connect.ust.hk; tanqiaowenapply@126.com; phkywong@ust.hkg; tschoi@eduhk.hk (Corresponding authors)*

Accurate prediction of landing time delays for inbound flights to airports is essential to maintain airport management efficiency and passengers' experiences. The situation is complicated by vectoring and holding patterns when the air traffic is heavy, and deviations from the standard terminal arrival routes. This paper proposes the steps needed for accurate prediction of landing time delays, using data of the Hong Kong International Airport. First, we characterize the standard flight times for flights approaching from different directions. Second, we extract features affecting the landing time delays, such as queue length of flights waiting for landing in the zone, the count of flights entering the zone, and recent average flight time delays. Third, we construct machine-learning models, reducing the average prediction error to around 3 minutes, which is as low as half of the hourly expected landing time delay from a distance of 200 km.

Keywords: Landing time delay, standard flight time, holding, Hong Kong International Airport, XGBoost

## SESSION C2: Stochastic Traffic Flow Modeling

# TRAFFIC STATE DISTRIBUTIONAL ESTIMATION BASED ON STOCHASTIC PHYSICS-INFORMED DEEP LEARNING

A. T. WANG [a], B. D. NGODUY [b*], C. T. DANTSUJI [b] and D. Y. LI [a]
[a] *College of Transportation Engineering, Tongji University, Shanghai, China*
[b] *Department of Civil Engineering, Monash University, Melbourne, Australia*
**Email: Dong.Ngoduy@monash.edu (Corresponding author)*

Physics-informed deep learning (PIDL)-based models have recently garnered remarkable success in traffic state estimation (TSE). Observed from these efforts was their deterministic nature striving to pursue two seemingly contradictory objectives: the interpretability and the accuracy. However, a solely deterministic physical within PIDL-based TSE framework fails to include the prevalent dynamical randomness effects that have been observed empirically. Typically, such models are trained to generate single state data as an estimated value for each spatiotemporal point within the spatiotemporal domain, lacking information on estimation uncertainty. To solve this problem, this paper proposes a novel stochastic PIDL (SPIDL) method for traffic state distributional estimation. Specifically, the stochastic fundamental diagram is adopted to characterize the stochastic process and capture the scattering effects between traffic state variables. And it serves as the constraint for the backpropagation calculation process of the neural network, guiding the training and learning process. Comparative experiments based on the real-world Next Generation Simulation (NGSIM) dataset are conducted across various scenarios characterized by different levels of detection data sparsity, as well as employing both first-order LWR and second-order ARZ traffic flow models to validate the versatility and efficacy of SPIDL. The results underscore the applicability and effectiveness of proposed SPIDL in sparse detection data scenarios. SPIDL-LWR and SPIDL-ARZ can achieve accurate and robust estimation, with the randomness effect being well captured.

Keywords: Traffic state estimation; Physics-informed deep learning; Stochastic fundamental diagram; Distributional estimation

# DEVELOPING AND SOLVING A STOCHASTIC SECOND-ORDER TRAFFIC FLOW MODEL BASED ON MULTI-ELEMENT PROBABILITY COLLOCATION METHOD

A. Xi CHEN [a], B. S.C. WONG [a*] and C. Liangze YANG [b]
[a] *Department of Civil Engineering, The University of Hong Kong, Hong Kong SAR, China*
[b] *School of Mathematical Sciences, Anhui University, Hefei, Anhui, China*
**Email: hhecwsc@hku.hk (Corresponding author)*

Traffic flow models serve as a fundamental tool for effective traffic surveillance and control, flow prediction, and optimal management strategies. Conventional hydrodynamic models, which deterministically describe the equilibrium between traffic flow and density, often fail to account for the stochastic variability inherent in driver behavior under real-world conditions. This oversight underscores the necessity for traffic flow models that incorporate stochastic elements. The goal of this paper is to develop a framework for analyzing stochasticity in driver heterogeneity in second-order macroscopic traffic flow models. Two adaptive Multi-Element Probabilistic Collocation Methods (ME-PCMs) are proposed for efficient numerical solutions. The Payne-Whitham (PW) model is employed as a test case, and the methods are evaluated against Monte Carlo (MC) benchmarks. The numerical results demonstrate high accuracy and efficiency of both adaptive methods, particularly with an adaptive level of $\theta 1 = 0.001$. The nested sample nodes from the bisection splitting process enhance computational efficiency, providing an efficient approach to simulate traffic dynamics under stochastic conditions. Future work will focus on multiple random parameter stochastic traffic flow problems to simulate the traffic flow evolution for improved traffic management.

Keywords: Stochastic Traffic Flow, Second-order Hydrodynamic Models, Polynomial Chaos Expansions, Adaptive Multi-element Probability Collocation Method

# PRACTICAL VEHICLE ROUTING IN AN URBAN ROAD NETWORK: IS STOCHASTIC OR TIME-DEPENDENT SPEED IMPORTANT?

A. Stein W. WALLACE [a*], B. Feng GUO [b*], C. Zhaoxia GUO [b*] and D. Michal KAUT [c]

[a] *Norwegian School of Economics, Norway*

[b] *Sichuan University, China*

[c] *SINTEF Technology and Society, Norway*

[*] *Email: stein.wallace@nhh.no; gfeng@stu.scu.edu.cn; zx.guo@alumni.polyu.edu.hk (Corresponding author)*

Vehicle routing, in all its variants, is one of the most studied problems in logistics. But for historical as well as numerical reasons, the vast majority of papers are on deterministic problems. Stochastic versions have started to occur. The most studied stochastic phenomenon is demand, followed by travel time (speed), service time and finally, random occurrence of customers. We analyze a variety of vehicle routing problems where travel speed is stochastic across time and space. Using real maps and real speed data for the mega-city Chengdu, China, we ask two questions. 1) Is time dependence of speed important and 2) Is stochastics important? We study the questions with respect to both decisions and out-of-sample objective values in order to understand the actual behavior of solutions. While time dependence is important most of the time, stochastics is not. Hence, we analyze and characterize which VRP formulations are sensitive to stochastic speeds and which are not. We solve with an accuracy of about 1\% VRPs with 6000 links, 240 time periods and 100 customers, resulting in over 1.4 million dependent random variables.

Keywords: Vehicle routing, Large-scale dependent random speeds, Scenarios

# UNCERTAINTY QUANTIFICATION APPROACHES OF MACROSCOPIC FUNDAMENTAL DIAGRAMS IN URBAN NETWORKS

A. Wenfei MA [a], B. Yunping HUANG [b], C. Xiao JIN [a] and D. Renxin ZHONG [a*]
[a] *School of Intelligent Systems Engineering, Sun Yat-Sen University (Shenzhen Campus), China*
[b] *Department of Civil and Environmental Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
[*] *Email: zhrenxin@mail.sysu.edu.cn (Corresponding author)*

The well-defined (deterministic) macroscopic fundamental diagram (MFD) is widely applied in network-level traffic control and management. However, scattering and hysteresis effects are widely observed in empirical and simulation data. Such uncertainty that is not captured by the deterministic MFD model may lead to suboptimal control and management strategies. This paper proposed two approaches to quantify the uncertainty associated with the MFD. The first approach assumes that the uncertainty results from the stochasticity in the model parameters, while these model parameters were assumed to follow a Gaussian distribution. In the second approach, a novel objective function is formulated to eliminate the assumption of the pre-defined distribution of parameters, achieving a more flexible and precise quantification of the uncertainty. The two uncertainty quantification approaches are compared and the associated MFDs are calibrated using simulation data from two cities in China. Both approaches can capture the uncertainty associated with the MFD while the first approach provides an alternative to calibrating the MFD under network loading/unloading within a flexible framework. Simulation results also reveal that travel demand and control strategies contribute to the hysteresis loops associated with MFD uncertainty. Therefore, the proposed uncertainty quantification approaches can facilitate the evaluation of demand-side and supply-side network resilience.

Keywords: Macroscopic fundamental diagram, Uncertainty quantification, Hysteresis

# STOCHASTIC ORIGIN-DESTINATION DEMAND ESTIMATION FROM STOCHASTIC LINK COUNTS ON UNCONGESTED NETWORKS

A. Jiaqi LIU [a], B. Zheng LIANG [a*] and C. Hong K. LO [a]

[a] *Department of Civil and Environmental Engineering,*

*The Hong Kong University of Science and Technology, Hong Kong S.A.R., China*

[*] *Email: zliangam@connect.ust.hk (Corresponding author)*

Understanding the origin-destination (OD) demand is crucial for efficient transport operations but is a challenging problem since large-scale OD surveys are very costly. Estimating the OD demand of a traffic network usually involves adjusting a prior OD demand by minimizing the difference between the observed and estimated traffic counts. While the existing literature has developed various models for OD estimation, they generally focus on deterministic approaches, neglecting the underlying demand stochasticity. To address this fundamental issue, this study proposes a Bayesian inference framework to estimate the stochastic OD demand using link counts with variations observed over a period on the uncongested network. The posterior functions of the distribution parameters are formulated based on the Bayes theorem. The OD demand is assumed to follow a normal distribution with known variance, and its mean is modeled with a conjugate prior distribution following a normal distribution. The stochastic user equilibrium traffic (SUE) assignment model is applied to obtain the route choice probabilities, from which the prior distribution of link counts is then derived. Subsequently, the posterior parameters of link counts are formulated based on the proposed functions and used to facilitate the inverse derivation of the posterior OD distribution parameters. By considering the demand parameters as random variables, the model can capture the stochastic characteristics of the OD demand. The maximum likelihood estimation (MLE) method is applied for comparative analysis to assess the efficiency of the Bayesian framework. A case study using a small network is conducted to demonstrate the validity and performance of the proposed model.

Keywords: stochastic OD estimation, link counts, trajectory data, stochastic user equilibrium, Bayesian estimation

SESSION C3: Automated Vehicle Behavior and Safety

# INFLUENCES OF INDIVIDUAL HETEROGENEITY ON VEHICLE DAMAGE IN TWO-VEHICLE LANE-CHANGING RELATED CRASHES: A COPULA-BASED MODEL

A. Ruifeng GU [a*] and B. N.N. SZE [a*]

[a] *Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hong Kong*

[*] *Email: griffer.gu@connect.polyu.hk; tony.nn.sze@polyu.edu.hk (Corresponding authors)*

Lane changing behaviour occurs frequently on the highways. However, it also poses a major impact on traffic operation and safety since complex interactions between two or more vehicles on different traffic lanes are involved. In the lane-changing related crashes, correlation in damage level among the vehicles involved is prevalent. To this end, a copula approach is proposed to model the vehicle damage level of lane-changing related crash, with which the dependency between lane-changing and lane-keeping vehicles is accounted for. Additionally, a semi-parameter estimation approach is adopted to address the problem of heterogeneous data structure. In this study, crash data from Orlando City of Florida during the period between 2016 and 2019 are used. Then, the semi-parameter copula-based ordered logit models are estimated to measure the association between road environment, vehicle attributes, driver characteristics, crash circumstances, and vehicle damage level of two-vehicle lane-changing related crashes. Additionally, temporal instability is also considered. Results indicate that there are major discrepancies in the influences of possible factors on vehicle damage level between lane-changing and lane-keeping vehicles. Furthermore, non-linear relationships between vehicle damage level, driver age, and time of crash are also revealed. Findings should shed light on effective remedial measures that can reduce the risk of vehicle damage in lane-changing related crashes.

Keywords: Copula model, Ordered logit model, Vehicle damage severity, Lane-changing behaviour, Heterogeneous data

As at December 7, 2024

# TRANSPORTATION SAFETY-BASED OBSTACLE DETOUR PATH PLANNING METHOD FOR AUTOMATED VEHICLES

A. Quan YUAN [a*] and B. Jun LI [b,c]

[a] *State Key Laboratory of Intelligent Green Vehicle and Mobility, School of Vehicle and Mobility, Tsinghua University, Beijing, China*

[b] *School of Automotive Engineering, Lanzhou Institute of Technology, Lanzhou, China*

[c] *School of Automotive and Transportation Engineering, Hefei University of Technology, Hefei, China*

**Email: yuanq@tsinghua.edu.cn (Corresponding author)*

Behavioral decision-making is a crucial topic in the research of automated driving, which is an essential intermediate link in the automated driving system to take over the upper level perception and guide the lower level planning. The research on behavioral decision-making of automated driving has important research significance and application value for improving the intelligence and safety of automated vehicles and promoting the broader development of automated vehicles. In view of the current research on deep reinforcement learning in the field of automated driving, this paper adopts the Soft Actor-Critic (SAC) reinforcement learning algorithm framework, which has the advantages of rapid convergence and robustness, to design a behavioral decision-making system based on the modularized automated driving scheme. Compared with many current "end-to-end" research solutions, the modular system is easier to maintain and debug, while the decision-making strategy of the model is still planned and then executed to ensure the rationality and executability of the actions. Based on path planning, dynamic planning based on the ST diagram is used to obtain a rough solution of the speed planning curve, and then quadratic planning is used to optimize the speed curve and path boundaries to achieve a safe, stable and efficient obstacle bypassing process.

Keywords: obstacle bypass; Soft Actor-Critic (SAC) reinforcement learning algorithm; quadratic planning

# RTCROWD: REAL-TIME CROWD SIMULATION IN THE IMMERSIVE VIRTUAL ENVIRONMENT

A. H. LIANG [a*], B. M. O. WONG [b] and C. J. SUN [a*]
[a] *College of Transportation Engineering, Tongji University, China*
[b] *Department of Civil and Environmental Engineering, University of Macau, Macau SAR, China*
**Email: lianghy@connect.hku.hk; sunjian@tongji.edu.cn (Corresponding authors)*

Utilizing crowd simulation models within virtual reality (VR) has proven effective for conducting human-centric studies, such as those involving sensory analysis of building environment and safety evaluation of fire evacuations. Many studies have sought to deepen the immersive experience of real individuals by integrating Immersive Virtual Environment (IVE) with crowd simulation technologies. However, there is still a lack of interactivity between simulation and real humans, the so-called HumanIn-Loop (HIL) testbed, in immersive environments. The major difficulty in realizing this testbed lies in the following two aspects. First, it is difficult for simulation models to understand the semantic information of buildings' models. Second, the commonly used agent-based model is time-consuming in calculating route information for a sufficiently large number of virtual pedestrians. This study proposes RTCrowd, which integrates Building Information Modeling (BIM)with a macro-micro simulation engine to achieve the construction of an immersive virtual simulation framework involving real humans. A systematic introduction of RTCrowd framework is presented, comprising a BIM-driven navigational graph construction, Potential Field Model (PFM) at the macroscopic level, a Modified Social Force Model (M-SFM) at the microscopic level, and working flow of the HIL framework. Additionally, a case study based on a real underground station is performed in the CAVE Lab. The comparative analysis of computational efficiency and movement characteristics reveals a significant enhancement over baseline simulation-based virtual environments. This framework is positioned as a significant step forward in the integration of VR and crowd simulation, offering more reliable platforms for exploring human behavior in simulation-based experiments.

Keywords: crowd simulation, virtual reality experiments, Immersive Virtual Environment, Building Information Modeling

# A HYBRID CALIBRATION METHOD OF PARAMETERS IN MICROSCOPIC PEDESTRIAN BEHAVIORAL MODELS UNDER HIGH-DENSITY WALKING ENVIRONMENT

A. Soyeon LEE [a], B. Jihye BYUN [a], C. Haoyang LIANG [b] and D. Seunghyeon LEE [a*]

[a] *Department of Transportation Engineering, The University of Seoul, Seoul, Republic of Korea*

[b] *Key Laboratory of Road and Traffic Engineering, Tongji University, Shanghai, China*

** Email: Seunghyeon.lee@uos.ac.kr (Corresponding author)*

This article focuses on investigating a calibration methodology for microscopic pedestrian dynamic models that seamlessly integrates an unsupervised machine learning mechanism and a Genetic Algorithm (GA). The proposed calibration method underscores the persistent need for improved calibration methods to enhance both efficiency and accuracy in simulating and predicting crowd dynamics under diverse scenarios. This study presents three primary contributions: 1) Development of a hybrid recursive method for calibrating behavioral parameters of pedestrians within the modified SFM, considering the nuanced variations in moving crowd density, velocity, and geometric boundaries, particularly under conditions of high crowd density. 2) Utilization of the Pedestrian Dynamics Data Archive (PDDA) to validate the effectiveness of the developed method, calibrating behavioral parameters across a comprehensive range of pedestrian flow conditions, from free-flow to congested scenarios. 3) Enhancement of SFMs with well-calibrated behavioral parameters for each pedestrian group clustered based on the pedestrian fundamental diagram, providing a fine-grained spatiotemporal representation of pedestrian dynamics.

Keywords: Moving crowd density, Social force model, Hybrid recursive calibration methods, k-means clustering, pedestrian dynamics

As at December 7, 2024

# HUMAN-LIKE INTERACTIVE LANE-CHANGE MODELING BASED ON REWARD-GUIDED DIFFUSIVE PREDICTOR AND PLANNER

A. Kehua CHEN [a*], B. Yuhao LUO [b], C. Meixin ZHU [b] and D. Hai Yang [c]
[a] *Division of Emerging Interdisciplinary Areas (EMIA), Academy of Interdisciplinary Studies, The Hong Kong University of Science and Technology, Hong Kong, China.*
[b] *Intelligent Transportation Thrust, The Hong Kong University of Science and Technology (Guangzhou), Guangzhou, China*
[c] *Civil and Environmental Engineering Department, The Hong Kong University of Science and Technology*
**Email: kchenbm@connect.ust.hk (Corresponding author)*

Lane changing presents a dynamic scenario characterized by intricate interactions among vehicles. Within mixed-autonomy traffic environment, modeling a human-like lane-change trajectory enables human drivers to better understand and predict autonomous vehicles' behaviors, thereby enhancing road safety and travel efficiency. In this study, we achieve human-like interactive lane-change modeling based on a novel framework named Diff-LC. The human-like modeling of LCV behaviors relies on an advanced diffusive planner, and the implemented trajectory is selected based on the recovered LCV reward function learned through Multi-Agent Adversarial Inverse Reinforcement Learning (MA-AIRL). To account for interactions between FVs and LCVs, we further employ a diffusive predictor to forecast future behaviors of FVs conditioned on both historical and planned trajectories. Additionally, we leverage the recovered reward function of FVs to enable controllable prediction of trajectories. In the experimental part, we begin by comparing the distinctions between the LCV and the FV. To validate the effectiveness of the proposed framework, we compare the diffusive predictor and planner with several state-of-the-art methods. The results demonstrate that motions planned by Diff-LC closely reach the intended positions with small displacement errors and exhibit highly similar speed and jerk distributions to those of human drivers.

Keywords: Lane Changing, Human-Like Modeling, Diffusion Model, Trajectory Prediction

## SESSION C4: Public Bus System Optimization

# INVESTIGATING THE UNIQUE DRIVING PATTERNS OF PUBLIC LIGHT BUS IN HONG KONG

A. H.Y. TONG [a*] and B. S.M.S. YUEN [b]

[a] *Department of Engineering Systems and Supply Chain Management, Aston University, UK*

[b] *College of Professional and Continuing Education, The Hong Kong Polytechnic University, Hong Kong SAR, China*

**Email: tongh1@aston.ac.uk (Corresponding author)*

Due to the fundamental differences in the technology adopted, the emission and energy consumption profiles of vehicles using alternative fuels are different, which motivates the need to identify the driving patterns (or driving cycles) for different vehicle types. In Hong Kong, driving cycles have been developed for different vehicle types since about 25 years ago, covering from light duty vehicles to traditional double decked buses and electric buses. Other existing driving cycle studies elsewhere involving alternative fuel or electric vehicles (EVs) did not provide direct comparisons using the same geographical locations. The public light bus (PLB) services are currently playing important roles in the public transport system in Hong Kong, however, no published scholarly studies looked into the driving patterns of this distinctive mode of urban transport. Therefore, this study aimed to investigate the driving patterns of PLB services under the unique driving conditions in Hong Kong. A fixed-route PLB service deployed with electric and LPG minibuses was selected to collect on-road driving data during normal daily operations. This enabled a direct comparison between these two alternative fuel technologies along exactly the same route. The identified driving patterns would also be compared with driving cycles developed for other vehicle types in Hong Kong so as to illustrate the impact of PLB electrifications on driving performances. Findings from this study are expected to offer valuable insights for government authorities and PLB operators in devising strategies for the deployment of PLBs with different alternative fuel technologies in Hong Kong and other regions.

Keywords: Public Light Bus, Vehicle Driving Patterns, Public Transport Electrification, Driving Cycles, Vehicle Emissions and Fuel Consumption, Electric Vehicles

**STRATEGIES FOR QUEUE-BASED SKIP-STOP SCHEME IN EXCLUSIVE MEDIAN BUS LANE**

A. Hee-Dong HA [a], B. Sooyeon PARK [a*] and C. Do-Gyeong KIM [b*]
[a] *Department of Transportation Engineering, University of Seoul, Korea*
[b] *Department of Transportation Engineering & Graduate School, Department of Urban Big Data Convergence, University of Seoul, Korea*
**Email: cjswltndus@uos.ac.kr; dokkang@uos.ac.kr (Corresponding authors)*

The exclusive median bus lanes (EMBL) are critical for regional transportation networks in metropolitan cities, but they have approached their functional limits due to the increasing traffic demand associated with urban densification and satellite city expansion. During peak hours, the concentrated passenger demand significantly increases delays at bus stops, causing even the highest quality bus rapid transit systems to fall behind in competition with urban rail services. To reduce the travel time and to establish a sustainable public transportation system, it is necessary to identify the causes of traffic delays and develop efficient improvement strategies. This study secures Bus Management System (BMS) data, which contains accurate time information on bus arrivals and departures at stops, to demonstrate that queue lengths for entering bus stops affect increase travel time. The application of a skip-stop strategy, which can adjust the number of buses arriving at stops while maintaining the bus capacity of the system, was analyzed to reduce travel time compared to the current all stop operation. Skip-stop operation is efficient when comparing travel time, dwell time, additional travel time, and queue lengths as effectiveness measures. The skip-stop plan reduces travel time by 9.6% and queue lengths by 19 buses compared to the all-stop plan, though it requires additional travel time due to passengers not reaching their optimal stops. A skip-stop plan with hub stops, while less effective in reducing travel time by 7.6% and queue lengths 11 buses, is considered more practical given passenger convenience.

Keywords: Exclusive median bus lane, Skip-stop operation, Bus management system, Bus queue length, Additional travel time

# A MIXED-INTEGER PROGRAMMING-BASED Q-LEARNING APPROACH FOR ELECTRIC BUS SCHEDULING WITH MULTIPLE TERMINI AND SERVICE ROUTES

A. Yimo YAN [a], B. Yong-Hong KUO [a*], C. Andy H.F. CHOW [b],
D. Yang DENG [b,c] and E. Qihao WU [a]
[a] *Department of Industrial and Manufacturing Systems Engineering,*
*The University of Hong Kong, Hong Kong SAR*
[b] *Department of Systems Engineering, City University of Hong Kong, Hong Kong SAR*
[c] *School of Management, Xi'an Jiaotong University, China*
**Email: yhkuo@hku.hk (Corresponding author)*

Electric buses (EBs) are considered a more environmentally friendly mode of public transit. In addition to other practical challenges, including high infrastructure costs and short driving ranges, the operations of EBs are more demanding due to the necessary battery charging activities. Consequently, more sophisticated optimisation models and algorithms are required for effective operations. This paper presents an EB scheduling problem with multiple termini and service routes. Various realistic but complicated factors, such as shared facilities at multiple termini, the flexibility of plugging and unplugging chargers before an EB is fully charged, stochastic travel times, and EB breakdowns, are considered. We propose an integrated learning and mixed-integer linear programming (MILP) framework to overcome the computational difficulties when solving the problem. This framework leverages the strengths of reinforcement learning and MILP for fast computations due to its capability of learning from outcomes of state–action pairs and computational effectiveness guaranteed by the constraints governing the solution feasibility. Q-Learning and Twin Delayed Deep Deterministic Policy Gradient are adopted as our training methods. We conduct numerical experiments on artificial instances and realistic instances of a bus network in Hong Kong to assess the performance of our proposed approach. The results show that our proposed framework outperforms the benchmark optimisation approach, in terms of penalty on missed service trips, average headway, and variance of headway. The benefits of our proposed framework are more significant under a highly stochastic environment.

Keywords: Public transport, Mixed-integer linear programming, Q-learning

# DEVELOPING BUS SPEED PREDICTION MODEL FOR EXCLUSIVE MEDIAN BUS LANES CONSIDERING BUS TRAVEL DEMAND

A. Seungbin IM [a], B. Saehim KIM [a], C. Seunghwa JANG [a] and D. Joonho KO [a*]

[a] *Department of Urban and Regional Development,*

*Graduate School of Urban Studies, Hanyang University, Seoul, Republic of Korea*

[*] *Email: jko@hanyang.ac.kr (Corresponding author)*

Modern cities are facing various problems due to population growth and car-dependent transportation systems. In response, many are adopting transit-oriented development. For the effective implementation of these policies, it is important to forecast the demand and traffic flow of public transportation systems. Previous studies have primarily forecasted ridership at the stop or route level, and recent studies exploring lane-level traffic flows. However, these studies have neither captured the importance of bus speeds nor the necessary interactions required for an integrated understanding of urban transportation and spatial planning. This study utilizes Bus Management System(BMS) data and urban spatial structure data from Seoul's exclusive median bus lanes to address the previously unmet need for an integrated understanding of bus speed predictions and urban transportation system interactions through analysis at the link unit level between bus stops. The process involves four key steps. First, analyzing bus speed and travel patterns between stations using BMS data. Second, using analyzed data and urban spatial structure data to select important variables for bus stops and connectivity links analysis. Third, a regression analysis assesses each variable's impact and identifies critical factors. Finally, machine learning techniques are utilized to develop a model that predicts future bus demand and subsequent changes in road section speeds. By understanding bus travel demand and speeds on station section link units, new public transport link-based policies can be implemented. These evidence-based insights will promote sustainable development and offer new perspectives on solving issues such as overcrowding and traffic congestion.

Keywords: Bus Speed Prediction, Exclusive Median Bus Lanes, Bus Management System (BMS), Travel Demand Prediction, Urban Spatial Structure, Machine Learning in Transportation, Transit Oriented Development (TOD), Traffic Congestion Management, Traffic Flow Analysis

**SPATIAL-TEMPORAL TAXI PROFITABILITY THROUGH DATA PREDICTIVE ANALYTICS**

A. Cheuk Kin HO [a*], B. Enoch LEE [b*], C. Yue HUAI [a*] and D. Hong K. LO [a*]
[a] *Department of Civil and Environmental Engineering,*
*The Hong Kong University of Science and Technology, Hong Kong SAR, China*
[b] *Department of Logistics and Maritime Studies,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
[*] *Email: ckhoaf@connect.ust.hk; enoch.lee@polyu.edu.hk; ceyhuai@ust.hk;*
*cehklo@ust.hk (Corresponding authors)*

The profitability of taxi operations varies spatially and temporally. Despite its significance in driver decision-making, it remains inaccessible to most drivers or ride-hailing platforms. Based on historical data, this paper forecasts demand patterns and analyze its distribution spatially and temporally. The forecasting process encompasses multiple factors, including expected passenger demand, projected idle time, the likelihood of encountering traffic congestion, and estimated earnings. To aid taxi drivers in making informed decisions, visual guidance in the form of heatmaps is generated, highlighting positions with potential to yield a higher profitability. The dataset comprises taxi records from Hong Kong including trip origins and destinations. Besides, we decompose Hong Kong into various sub-zones to examine the profitability within each specific area by time. The result provides valuable assistance to taxi drivers by enhancing their operational decision-making and, consequently, improving their profitability.

Keywords: Taxi profitability, Spatial-temporal distribution, Predictive analytics, Data analysis

SESSION C5: Spatial-Temporal Traffic Modeling

# ROUTE CHOICE AND TRAFFIC EQUILIBRIUM CONSIDERING A DRIVER SUBOPTIMAL INFORMATION ACQUISITION STRATEGY: THE DELUDED RATIONAL INATTENTION APPROACH

A. Shuntaro MEGA[a*] and B. Daisuke FUKUDA[a*]

[a] *Department of Civil Engineering, The University of Tokyo, Japan*

**Email: mega-shuntaro699@g.ecc.u-tokyo.ac.jp; fukuda@civil.t.u-tokyo.ac.jp*

*(Corresponding authors)*

This study develops a novel traffic model referred to as the deluded rational inattention nested logit model (deluded-RINL model) to explore the suboptimal information strategy and travel behavior of drivers with imperfect knowledge. In addition, a corresponding traffic equilibrium model referred to as the deluded-RINL user equilibrium model is developed to investigate the effect of information provision on traffic flow. We perform a simple network simulation by assuming a return trip after a big event at a tourist destination. Tourists, as drivers, are assumed to have imperfect knowledge of traffic states, act on a suboptimal information strategy, and be affected by the provision of information and economic incentive measures such as coupons. The results suggest that the provision of information and coupons is an adequate means of dispersing traffic in many cases, but information may be counterproductive when information and coupon measures are jointly offered.

Keywords: Traffic information, Rational inattention, Travel choice, Traffic equilibrium

# INTRODUCING GEOGRAPHICALLY WEIGHTED LIGHTGBM (GWLGBM) MODELS: A NEW SPATIAL MACHINE LEARNING MODEL

A. Fan GAO [a*], B. Sylvia Y. HE [a] and C. Mei-Po KWAN [b]
[a] *Department of Geography and Resource Management, The Chinese University of Hong Kong, N.T., Hong Kong*
[b] *Institute of Space and Earth Information Science, The Chinese University of Hong Kong, N.T., Hong Kong*
**Email: gaofan@link.cuhk.edu.hk (Corresponding author)*

Analyzing spatially varying relationships constitutes a fundamental pursuit in geography, crucial for comprehending intricate spatial patterns. These relationships can arise from spatial heterogeneity, where processes exhibit variation across space, or from non-linearity, wherein relationships evolve across covariate ranges. To distinguish these diverse relationships, researchers have developed spatially varying coefficient models and machine learning techniques, each adept at discerning spatial variations and non-linear associations, respectively. However, when confronted with non-linear relationships that also exhibit spatial varying, both model types may produce misleading conditional relationships. To address this research gap, this study introduces geographically weighted LightGBM (GWLGBM) models, which integrate localized machine learning with spatial weighting in their methodologies. By integrating the SHAP (SHapley Additive exPlanations)—a local interpretable machine learning method—into the local calibration, we enhance the capability of GWLGBM models to identify both spatially varying and locally non-linear relationships. The combination of GWLGBM and SHAP methods can avoid the misinterpretation of spatial variation as non-linearity and vice versa. We evaluate the efficiency of our proposed approach on three simulated datasets and a real-world dataset. The results show that our new model outperforms mainstream machine learning, e.g., LightGBM, and spatial statistical models, e.g., multiscale geographically weighted regression, in terms of discerning spatially heterogeneous effects and capturing local non-linear associations, particularly when spatial heterogeneity and non-linearity coexist. Our empirical analysis yields valuable insights into leveraging this combined methodology to elucidate complex geographical phenomena, highlighting its potential to understand locally varying relationships in spatial data.

Keywords: spatial varying relationship, non-linear relationship, LightGBM, interpretable machine learning.

# FROM INCOMPLETE DATA TO FULL-SCALE TRAFFIC PREDICTION: AN ITERATIVE FRAMEWORK WITH DIRECTION-BASED TRAFFIC DATA

A. R. CAO [a] and B. David Z.W. WANG [a*]
[a] *School of Civil and Environment Engineering, Nanyang Technological University, Singapore*
[*] *Email: WangZhiwei@ntu.edu.sg (Corresponding author)*

This paper presents a novel framework to tackle the prevalent challenges in traffic prediction, particularly the lack of complete datasets and the omission of directional monitoring data in existing models. Typically, datasets with incomplete temporal or spatial data are excluded from prediction models, potentially causing the loss of crucial insights. To address these issues, our approach integrates data imputation and prediction into an iterative process, drifting away from the conventional methodology of treating these steps separately. Firstly, we introduce an innovative road network construction method that utilizes detection direction and dynamic distance thresholds, significantly enhancing the spatial and temporal representation of traffic networks. This is further augmented by a direction-based dynamic graph construction that employs an intertwined pairwise dynamic time-warping (PDTW) matrix and convolutional neural networks (CNNs). This combination remarkably improves the extraction and integration of spatio-temporal features, especially from sensors lacking comprehensive spatial data. Then, our iterative framework leverages predictions from the previous day to inform data imputation for the current day, which in turn enhances the prediction accuracy for the following day. Experimental results confirm that this integrated approach consistently improves prediction accuracy across various scenarios, demonstrating its practical effectiveness and efficiency. This paper establishes a new framework for traffic data completion and prediction, significantly enhancing traffic management and urban planning strategies.

Keywords: Traffic Prediction, Incomplete Data, Spatial-Temporal Relationships, Iterative Completion and Prediction, Deep Learning

# TRAFFICGPT: VIEWING, PROCESSING AND INTERACTING WITH TRAFFIC FOUNDATION MODELS

A. Siyao ZHANG [a], B. Daocheng FU [b], C. Wenzhe LIANG [a], D. Zhao ZHANG [a*], E. Bin YU [a], F. Pinlong CAI [b] and G. Baozhen YAO [c]

[a] *School of Transportation Science and Engineering (Beihang University)*

[b] *Shanghai Artificial Intelligence Laboratory*

[c] *School of Transportation and Logistics (Dalian University of Technology)*

[*] *Email: zhaozhang@buaa.edu.cn (Corresponding author)*

With the promotion of chatgpt to the public, Large language models indeed showcase remarkable common sense, reasoning, and planning skills, frequently providing insightful guidance. These capabilities hold significant promise for their application in urban traffic management and control. However, large language models (LLMs) struggle with addressing traffic issues, especially processing numerical data and interacting with simulations, limiting their potential in solving traffic-related challenges. In parallel, specialized traffic foundation models exist but are typically designed for specific tasks with limited input-output interactions. Combining these models with LLMs presents an opportunity to enhance their capacity for tackling complex traffic-related problems and providing insightful suggestions. To bridge this gap, we present TrafficGPT—a fusion of multiple LLMs and traffic foundation models. This integration yields the following key enhancements: 1) empowering LLMs with the capacity to view, analyze, process traffic data, and provide insightful decision support for urban transportation system management; 2) facilitating the intelligent deconstruction of broad and complex tasks and sequential utilization of traffic foundation models for their gradual completion; 3) aiding human decision-making in traffic control through natural language dialogues; and 4) enabling interactive feedback and solicitation of revised outcomes. By seamlessly intertwining large language model and traffic expertise, TrafficGPT not only advances traffic management but also offers a novel approach to leveraging AI capabilities in this domain. The TrafficGPT demo can be found in https://github.com/lijlansg/TrafficGPT.git.

Keywords: LLM, ITS, traffic management, supported decision-making

# CONTINUOUS NETWORK-WIDE FLOW AND DENSITY ESTIMATIONS BASED ON SHOCKWAVE DYNAMICS

A. El BUKHARI [a], B. L. KATTAN [a*], C. W. H. K. LAM [b] and D. W. MA [b]
[a] *Department of Civil Engineering, Schulich School of Engineering,*
*University of Calgary, Alberta, Canada*
[b] *Department of Civil and Environmental Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
[*] *Email: lkattan@ucalgary.ca (Corresponding author)*

Traffic state estimation at the link level has traditionally relied on either machine learning or simplified interpolation methods, which often lack a strong theoretical foundation. On the other hand, network-wide models either oversimplify traffic conditions or demand high computational resources, especially in microscopic simulations. This paper proposes a novel modeling approach grounded in shockwave theory to estimate continuous flows and densities across traffic networks using point sensor data, such as from loop detectors. The model aims to balance accuracy and computational efficiency by avoiding the pitfalls of high-order complexity and unnecessary assumptions. While classical papers in shockwave theory tend to utilize shockwave dynamics for link-level analysis of the impact of incidents, this paper first expands the dynamics to solve any event concerning shockwaves (whether waves meeting, passing through junctions, etc.). Afterwards, a model with a wholistic approach is proposed to utilize these dynamics in estimating network-wide flows and densities using point detector observations. A toy network was simulated using SUMO to validate the model. Results demonstrate that the proposed approach accurately captures shockwave dynamics and their impact on traffic conditions, requiring only retroactive corrections when waves are initially detected and significantly reducing computational cost compared to microscopic simulations. This promising model seems to offer a practical solution for real-time, network-wide traffic state estimation.

Keywords: Shockwave Theory, Real-Time Flow Estimation, Flow Theory

# MOBILITY CHANGES UNDER WORK FROM HOME CONDITIONS: THE CASE OF MALTA

A. Maria ATTARD [a*]
[a] *Department of Geography, University of Malta, Malta*
[*] *Email: maria.attard@um.edu.mt (Corresponding author)*

There is an urgent need to shift to more sustainable mobility practices to tackle environmental, public health and equity concerns. Work from home took center stage during the last global pandemic due to the forced lock downs and restrictions. Changes in cities were observed and technologies flourished to support workers and students who could not travel. Many have studied the response from employers and educators in different geographies and suggested pathways of practices and policies. The pandemic managed to reduce traffic from cities, however this was short-lived with many cities recording pre-pandemic levels as early as 2021. The study presents a case study from the islands of Malta and looks at the mobility changes of individuals under work from home conditions. It aims to identify benefits which accrued over time and which could be taken forward and enhanced for the benefit of cities, public health and the environment. This research is based on a survey of the local population conducted in December 2020, 2021 and 2022. It collected information about travel patterns and looked at the ICT tools which were employed to support shifting of work and school activities. The survey also looked at collecting information about individual travel expectations and the likelihood of teleworking in the future. The study is complemented by a review of local reports related to remote working to better contextualize the research outputs. The study concludes with valuable insights for both transport and environmental policies in Malta, but also in other similar island contexts.

Keywords: work from home, Malta, practices, teleworking, travel expectations

## SESSION C6: Spatial-Temporal Traffic Modeling

# SPATIAL-TEMPORAL MULTI-TASK LEARNING FOR SHORT-TERM PASSENGER INFLOW AND OUTFLOW PREDICTION ON HOLIDAYS IN URBAN RAIL TRANSIT SYSTEMS

A. Hao QIU [a] and B. Jinlei ZHANG [b*]
[a] *School of Traffic and Transportation, Beijing Jiaotong University, Beijing, China*
[b] *School of Systems Science, Beijing Jiaotong University, Beijing, China*
**Email: zhangjinlei@bjtu.edu.cn (Corresponding author)*

The rapid growth of passengers has led to overcrowding in urban rail transit (URT) systems, especially during holidays, posing significant challenges to the safe management and operation of URT systems. Accurate and real-time short-term passenger inflow and outflow prediction on holidays is essential for operation management and resource allocation to alleviate such overcrowding. However, short-term passenger inflow and outflow prediction on holidays is a challenging task influenced by various factors, including temporal dependencies, spatial dependencies, the temporal evolution of spatial dependencies, the interaction between inflow and outflow, and the limited holiday samples. To address these challenges, we propose a Spatial-Temporal Multi-Task Learning (STMTL) for short-term passenger inflow and outflow prediction on holidays in URT systems. STMTL comprises three parts: (1) Multi-Graph Channel Attention Network (MGCA) extracts both static and dynamic spatial dependencies from inter-station interaction graphs and then adaptively integrates multi-graph features. (2) Time Encoding-Gated Recurrent Unit (TE-GRU), utilizes time encoding gates to capture long-term periodic variations and unique fluctuations caused by holidays. (3) Cross-attention block (CAB) captures complex interactions during holidays and facilitates the sharing of spatiotemporal features between passenger inflow and outflow. To evaluate the effectiveness and robustness, STMTL is tested on two real-world datasets from the Nanning URT system in China during the New Year's Day period and compared with several classic models and state-of-the-art models. The results demonstrate that STMTL outperforms all baseline models, indicating its potential for practical applications in short-term passenger inflow and outflow prediction on holidays in URT systems.

Keywords: passenger inflow and outflow prediction, holiday passenger flow prediction, deep learning, multi-task learning

# DEEP REINFORCEMENT LEARNING FOR SOLVING THE INTEGRATED AIRLINE RECOVERY PROBLEM

A. Qi WANG [a], B. Xin WEN [a*] and C. Sai-ho CHUNG [a]

[a] *Department of Industrial and Systems Engineering, The Hong Kong Polytechnic University, Hong Kong SAR, China*

**Email: windy.wen@polyu.edu.hk (Corresponding author)*

Airline schedules can rarely go exactly as planned due to unpredictable disruptions, which can directly lead to flight delays and cancellations, causing significant financial losses to airline companies. An efficient airline recovery model should simultaneously consider the recovery decisions of various entities, and this integrated recovery is viewed as a significant and highly complex issue that requires high-quality solutions in a short time frame. With the development of reinforcement learning, it is considered to have great potential in learning decision-making for combinatorial optimization. In this paper, an integrated recovery problem is developed which will address both crew and aircraft recovery stages simultaneously using various recovery decisions related flights, crew and aircraft. Given the computational complexity of the integrated model, an attention model based end-to-end Deep Reinforcement Learning (DRL) framework is presented to learn a parameterized stochastic policy for daily recovery problems. Specifically, the parameterized stochastic policy can automatically select a flight for each entity step by step, and construct a solution which accommodates the aircraft, crew and schedule constraint. Finally, the policy gradient with rollout baseline is utilized to train the stochastic policy. Numerical experiments based on randomly generated instances are conducted to test the advantages of the proposed method in comparison to the current existing approaches.

Keywords: flight disruption, airline disruption, airline recovery

# A REINFORCEMENT LEARNING METHOD TO SOLVE DYNAMIC TRUCK-DRONE ROUTING PROBLEM

A. Wenbo SUN [a*] and B. Fangni ZHANG [a*]
*Department of Industrial and Manufacturing Systems Engineering,*
*The University of Hong Kong, China*
**Email: sunwb@connect.hku.hk, fnzhang@hku.hk (Corresponding author)*

This paper develops a reinforcement learning method to solve the dynamic routing problem of a truck-and-drone collaboration system with multiple types of tasks. Specifically, the collaboration system considers a post-disaster scenario. On the one hand, trucks and drones can deliver necessary relief logistics (medicine, food, and water) to the affected people. On the other hand, drones, with small cameras onboard, can perform surveillance tasks to assess the network and find new demand after disasters. Trucks and drones can collaborate on serving all demands. As new demands may arrive during the rescue process, the route of trucks and drones should be updated to rescue more people. In this paper, we develop a reinforcement learning method to solve the proposed problem in real time. Since the problem is an NP-hard problem with a large state and action space, the attention mechanism is adopted for the state representation. In numerical studies, we extensively compare the proposed reinforcement learning methods with other methods.

Keywords: Truck-and-drone, delivery and surveillance, vehicle routing optimization, reinforcement learning

# MACHINE-LEARNING-AIDED MIXED-INTEGER LINEAR PROGRAMMING FOR SOLVING TRANSPORTATION AND LOGISTICS PROBLEMS

A. Changlin LI [a*] and B. Hongbo YE [a*]
[a] *Department of Electrical and Electronic Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
**Email: changlin.li@connect.polyu.hk; hongbo.ye@polyu.edu.hk (Corresponding authors)*

Mixed-integer linear programming (MILP) techniques are widely used to solve transportation and logistics problems. State-of-the-art algorithms for solving MILP heavily depend on knowledge with unwritten intuition and handcrafted heuristics for its two most fundamental decisions: branching variable selection (i.e., the choice of the variable on which to branch) and node selection (i.e., selecting the next node to evaluate). which are mathematically not well defined or have high computational costs. To tackle this problem, this study proposes a novel machine-learning model for solving MILP problems, which can fully investigate the decision space, identify the best policy, and thus advance existing methods. We conduct experiments on five MILP benchmarks in the field of transportation and logistics (i.e., the capacitated facility location problem) and others, including both dual-difficult and primal-difficult problems. The results validate the effectiveness of our model and show that combining the two policies can lead to better performance compared to using either policy alone or the SCIP solver, demonstrating the potential of our approach for solving MILP problems.

Keywords: Transportation and logistics, Branch-and-bound, Mixed-integer linear programming, Machine-learning

# OPTIMIZING MOBILE FACILITY PLANNING FOR DISASTER RESPONSE WITH INEQUITY MITIGATION: A LEXICOGRAPHIC DISTRIBUTIONALLY ROBUST OPTIMIZATION APPROACH

A. Xinyao YU [a, b], B. Shoufeng MA [a, b], C. Ning ZHU [a*], D. Hongming LI [c] and E. Jintao KE [d]
[a] *College of Management and Economics, Tianjin University, Tianjin 300072, China*
[b] *Laboratory of Computation and Analytics of Complex Management Systems (CACMS), Tianjin University, Tianjin, 300072, China*
[c] *Army Military Transportation University, Tianjin 300161, China*
[d] *Department of Civil and Environmental Engineering, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, China*
[*] *Email: zhuning@tju.edu.cn (Corresponding author)*

In this paper, we study a novel mobile facility planning problem for disaster response, focusing on resource positioning, moving plans, and resource allocation strategies of mobile facilities. We address three critical aspects of humanitarian operations: uncertainty, adaptivity, and equity. Specifically, considering the sequence of demand realization and decision-making, we examine the adaptivity of resource allocation decisions and propose both static and adaptive formulations using a distributionally robust optimization (DRO) approach. For the static formulation, where allocation decisions are determined before demand realization, we analyze the model's structure and demonstrate that the worst-case distribution can be explicitly expressed as a joint discrete distribution without loss of optimality, allowing the problem to be equivalently reformulated as a MIP model. For the adaptive formulation, where allocation decisions are determined after demand realization, we prove that the allocation subproblem exhibits supermodularity, which enables us to reformulate the DRO model as a stochastic programming model with a polynomial number of scenarios. Based on these analytical results, we further delve into the issue of equity and extend both formulations into lexicographic optimization models. A Conditional Value-at-Risk-based column-and-constraint generation algorithm is introduced to exactly solve the lexicographic model. A case study of the Yushu earthquake provides managerial insights, emphasizing the robustness of the DRO model solutions and the value of adaptivity. Numerical results confirm that our lexicographic DRO model serves as a practical tool for decision-makers, balancing effectiveness and equity in humanitarian relief.

Keywords: Mobile facility, Humanitarian operation, Distributionally robust optimization, Lexicographic optimization, CVaR-based column-and-constraint generation

## SESSION D1: Bus Service Design and Optimization

# A MODIFIED GENETIC ALGORITHM FOR SOLVING THE BUS ROUTEDESIGN, EXPRESS BUS SERVICE DESIGN AND FREQUENCY SETTING PROBLEM

A. Q. HE [a*], B. W.Y. SZETO [a] and C. Y. WANG [b]

[a] *Department of Civil Engineering, The University of Hong Kong, China*

[b] *Civil and Natural Resources Engineering, University of Canterbury, Canterbury, New Zealand*

**Email: heloetta@connect.hku.hk (Corresponding author)*

Long commuting time is a common problem in large cities. Express bus service, which uses faster paths and skips several intermediate stops, is a potential solution to reduce the travel time, but it may increase thecost ofthe bus operator and affect the number of transfers. Most research is devoted to the express service design problem and the frequency setting problem without modifying the local bus routes. This study aims toreducethe total social costs by solving the bus network design, express service design, and frequency setting problems simultaneously. A hybrid genetic algorithm is modified to solve the integrated problem. A waypoint mechanism is added to ensure all the local routes do not skip any passing stations. The parameters arefinetuned, and various experiments are set up to demonstrate the properties and the performance of the solution algorithm. The numerical result shows that the solution obtained by designing the bus routes andexpressservice simultaneously is better than the sequential approach.

Keywords: Bus network design, Route design problem, Express service design problem, Frequencysettingproblem, Genetic algorithm

# BUS NETWORK DESIGN WITH THE INTEGRATION OF LIMITED-STOP AND AUTONOMOUS BUS SERVICES

A. Mingrui LIU [a*] and B. W. Y. SZETO [a]
[a] *Department of Civil Engineering, The University of Hong Kong, Hong Kong SAR, China*
**Email: mrliu@connect.hku.hk (Corresponding author)*

This study aims to solve the network design problem with the integration of limited stop service and consideration of autonomous bus operation to optimize both the total passenger travel time, the number of transfers, and the operator cost. This problem is modelled as a mixed integer nonlinear program and is NP-hard. A hybrid genetic algorithm is proposed in the solution methodology which can tackle the normal bus line design, limited stop service pattern design, autonomous bus line selection, and frequency setting problems simultaneously. The genetic algorithm solving the bus network design problem is hybridized with a line search heuristic which tackles the frequency setting problem and a pattern design heuristic which handles the explicit limited stop service design problem. Specific genetic mutation operators are developed to explore lines operated by autonomous buses. Compared with the base case of bus network design, the developed algorithm can generate a solution that can reduce the total passenger travel time, number of transfers, and operator cost simultaneously. Numerical experiments are also implemented to demonstrate the effect of the value of travel time.

Keywords: Bus network design; Limited-stop services design; Autonomous bus; Genetic algorithm

# INTEGRATION OF FLEXIBLE BUS AND PARCEL WITH AD HOC SERVICE UNDER STOCHASTIC DEMAND AND SERVICE TIME

A. Enoch LEE [a], B. Manzi LI [b*], C. Lubing LI [c] and D. Hong K. LO [c]
[a] *Department of Logistics and Maritime Studies,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
[b] *Civil and Environmental Engineering Department,*
*University of Michigan, Ann Arbor, United States*
[c] *Department of Civil and Environmental Engineering,*
*The Hong Kong University of Science and Technology, Hong Kong*
[*] *Email: manzil@umich.edu (Corresponding author)*

The growth of e-commerce has intensified pressures on urban freight systems, exacerbating traffic congestion and environmental impacts. Conversely, public transport often operates underutilized, presenting an opportunity to repurpose surplus capacity for parcel transportation. In response, we propose a dual-function flexible bus system that concurrently accommodates both passengers and parcels. This system is modeled through a stochastic optimization framework that accounts for the random spatial distribution, service time variability, and fluctuating demand volumes of passenger and parcel orders, addressing both routing and order assignment challenges. We employ a two-stage stochastic programming approach to optimize the joint provision of passenger and parcel services. The first stage focuses on strategic planning of bus routes and vehicle assignments, while the second stage adapts to real-time service requests from both passengers and parcels. A key feature of our solution methodology is the incorporation of reliability measures, which ensure service quality by accommodating constraints on vehicle detour time and load capacity. By optimizing these reliability measures, we refine the flexible routing and vehicle assignments to minimize operational costs. Our numerical studies demonstrate that this integrated approach not only boosts overall system efficiency but also outperforms traditional deterministic models, showcasing its potential for transforming urban transport logistics.

Keywords: co-modality, stochastic programming, flexible bus, parcel delivery

# A MULTI-PERIOD ASYMMETRIC TRANSIT FREQUENCY DESIGN

A. Jun GONG [a*] and B. Wai Yuen SZETO [a]
[a] *Department of Civil Engineering, The University of Hong Kong, China*
[*] *Email: jungong@connect.hku.hk (Corresponding author)*

Transit frequency design plays an important role in the performance of public transit services. In the literature, single-period frequency design is often considered but ignores the demand variation over time of day. Moreover, in high-demand bus networks, the demand patterns are asymmetric in both directions of some bus routes. This study investigates a bus operation strategy to address these two issues. In this strategy, for each route, a class of buses serves both two directions while the other class only serves one direction with high travel demand, leading to the two directions having different frequencies. Then, a multi-period asymmetric transit frequency design model is formulated, which allows the route frequencies of these two classes of buses to be adjustable in each period to address the demand variation over periods and demand asymmetry in some periods simultaneously. Deadhead trips between the bus depot and terminals or between terminals of different routes over the operating periods are also considered in the model formulation. An enhanced artificial bee colony algorithm is proposed to solve this problem. Numerical studies of the bus network of Tin Shui Wai are performed to illustrate the effectiveness of the algorithm introduced. The results indicate that the proposed algorithm can produce better solutions compared with the modified genetic algorithm. Moreover, the proposed method can produce a design that is better than the existing symmetric design in terms of passenger travel time, demand satisfaction, operating profit, and social welfare.

Keywords: Asymmetric transit frequency setting, Multi-period, Artificial bee colony algorithm

# ANALYSING BUS USAGE AND PUBLIC TRANSPORT ACCESSIBILITY IMPACTS FROM LONG-TERM CROWD-SOURCED TRAJECTORY DATA

A. Theeranai PULLARP [a*], B. Hyungsub JEE [a*], C. Jan-Dirk SCHMÖCKER [a*]
and D. Kari E. WATKINS [b]
[a] *Department of Urban Management, Graduate School of Engineering,*
*Kyoto University, Japan*
[b] *Department of Civil and Environmental Engineering, Graduate School of Engineering, University of California, Davis, USA*
**Email: theeranai.pullarp.78m@st.kyoto-u.ac.jp; hjee@trans.kuciv.kyoto-u.ac.jp;*
*schmoecker@trans.kuciv.kyoto-u.ac.jp (Corresponding authors)*

Crowd-sourced trajectory data collected through a mobile application introduces a viable new option to understand travel behaviour. In this study, we aim to analyse travel behaviour on public transit usage through such data. The "activity transition records" collected from 247 Puget Sound (Greater Seattle, Washington State, US) residents through an experiment with "OneBusAway" application are used. OneBusAway provides real-time public transit information to users and willing participants in the study agreed that their locational records are tracked. These locational information are limited to where and when participants change activities between "still", "walk", "cycling" and "in-vehicle". The strong point of the data is that the records are continuous and that participating users provide data over long-time periods as there is no notable impact on battery usage. As a first step, the study identifies likely bus trips from all the recorded in-vehicle trips by using open GTFS data and comparing these information to the time and location stamps of the activity transitions. The study is further able to identify 16 areas within the Puget Sound region where many in-vehicle trips start. Furthermore, the isochrones and isodistances for bus trips from the centroids of these areas are constructed. The results illustrate the importance of bus stop density and areas reachable by direct bus for the modal share of bus trips. The paper will further discuss the wider scope and potential benefits of the activity transition records as a new long-term travel behaviour data collection.

Keywords: Crowd-sourced trajectory data, OneBusAway, Long-term travel behaviour, Activity transition, Bus usage

SESSION D2: Smart Transportation Systems Optimization

# LEVERAGING VIIRS NTL DATA TO ASSESS THE IMPACT OF RAIL SYSTEMS ON JAPANESE CITIES

A. Heesoo KIM [a*], B. Nobuhiro UNO [a], C. Ryoji MATSUNAKA [a] and D. Tomoki NISHIGAKI [a]
[a] *Department of Urban Management, Kyoto University, Japan*
[*] *Email: kim.heesoo.24z@st.kyoto-u.ac.jp (Corresponding author)*

This study investigates the impact of Shinkansen connectivity on urban development across Japanese cities using Nighttime Light (NTL) data, a widely recognized proxy for urbanization and economic activity. The NTL data, collected by the Visible Infrared Imaging Radiometer Suite (VIIRS) aboard the Suomi National Polar-orbiting Partnership (Suomi NPP) satellite, is provided by the National Oceanic and Atmospheric Administration (NOAA) and is available as monthly composites from 2014 to 2023. Cities were classified based on their connection to the Shinkansen network into three categories: those with Shinkansen stations, those with only Shinkansen lines, and those without any Shinkansen infrastructure. The analysis reveals that cities with Shinkansen stations saw a 1.20% increase in NTL intensity, reflecting positive urban growth, whereas cities with only lines or no connections experienced declines of 3.00% and 2.49%, respectively. Moreover, the study found that cities with more recently opened Shinkansen stations demonstrated faster growth in NTL intensity, highlighting the significance of the timing of infrastructure development in driving urban expansion. The findings underscore the role of high-speed rail in fostering urban development, but also point to the need for future research to integrate additional economic indicators, such as GDP growth and employment rates, and to conduct detailed comparisons with population data. Additionally, given evidence that regional connectivity can sometimes lead to population decline in smaller cities, future studies should include a more granular analysis based on city size to better understand the differential impacts of Shinkansen connectivity on urban dynamics.

Keywords: NTL(Nighttime Light) data, High Speed Rail Impact, Shinkansen Connectivity

# MODEL CORRECTION BASED ON SELF-FEEDBACK ADJUSTMENT OF BULKY VEHICLE OVER-BRIDGE RESPONSE MONITORING DATA

A. Yucong MENG [a*], B. Wanshui HAN [a] and C. Shujun CHEN [b]

[a] *Highway Collage, Chang'an University, Xi'an, China*

[b] *Zhejiang Scientific Research Institute of Transport, Hangzhou, China*

[*] *Email: 1836148279@qq.com (Corresponding author)*

In recent years, the demand for bulky transportation has been increasing, and it is very important to establish the bridge calculation model quickly and accurately to ensure the safety of bulky transportation. For this reason, this paper proposes a model correction method based on the self-feedback adjustment of the response monitoring data of the bulky vehicle over the bridge, taking one of the two hollow slab bridges in Zhejiang Province, China, as an example, first of all, the two bridges are monitored for the deflection of the bulky vehicle over the bridge of 88t and 115t, and then through the self-feedback of the parameters generated by the monitoring data to determine the adjustment degree of the original model of the lateral distribution coefficients of each item for adjustment to ultimately achieve model The model can be corrected, and after several rounds of iteration, the theoretical value of the model and the monitoring value fall within the allowable error. The results show that the theoretical deflection value of the model after one correction under the corresponding bulky vehicle load has an improvement of about 12% in agreement with the monitoring value compared with the original model, which indicates that the adjustment of the lateral distribution coefficients through the self-feedback of the monitoring data to correct the model is conducive to the improvement of the agreement between the theoretical value and the monitoring value.

Keywords: Model correction, Self-feedback tuning, Iteration

# OPTIMAL DYNAMIC ALLOCATION PROBLEMS OF DEDICATED LANES FOR PEDESTRIANS IN A HETEROGENEOUS TRANSPORT NETWROK

A. Soyeon LEE [a], B. Jihye BYUN [a], C. Dong NGODUY [b] and D. Seunghyeon LEE [a*]
[a] *Department of Transportation Engineering, The University of Seoul, Republic of Korea*
[b] *Department of Civil Engineering, Monash University, Australia*
**Email: seunghyeonlee@uos.ac.kr(Corresponding author)*

The study proposes an optimization framework to explain the dynamic allocation problem of dedicated lanes for pedestrians under heterogeneous traffic conditions. Typically, the allocation of road space follows fixed rules without sufficiently considering the varying travel patterns and demands that change over time. In a multi-modal traffic environment, such static traffic networks can lead to inefficient space utilization and increased congestion. To address this issue, we suggest a method to reduce the congestion by reallocating road space in response to time-varying pedestrian demand generation. Our methodology was constructed using a mixed-integer linear program (MILP) to formulate and approximate the problem. We developed a testbed network to numerically evaluate the performance and efficiency of the dynamic lane allocation model for pedestrian. Moreover, we designed diverse traffic demand scenarios to confirm the stable performance of the proposed method under a variety of traffic conditions. Our results indicate that implementing dynamic lane allocation for pedestrians can effectively facilitate pedestrian flow within the network. This model not only can manage a traffic network with recurrent multimodal congestions, but also allows to adaptively response to non-recurrent dramatic changes in heterogeneous traffic demand generated from special events such as festivals and performances.

Keywords: Mixed-integer linear programming, Heterogeneous traffic conditions, Time-varying demand, Dedicated lanes, Dynamic allocation problems

# ASSESSMENT OF POTENTIAL SHARED SPACE STREET USING ANALYTIC HIERARCHY PROCESS (AHP): A CASE STUDY IN KLANG VALLEY, MALAYSIA

A. Nitya VISVANATHAN [a] and B. Hooi Ling KHOO [a*]
[a] *Department of Civil Engineering, Lee Kong Chian Faculty of Engineering and Science, Universiti Tunku Abdul Rahman, Selangor, Malaysia*
**Email: khoohl@utar.edu.my (Corresponding author)*

Shared Space Streets, a renowned concept embraced throughout European countries and Australia, are commended for their distinctive ability to unite people on a singular grade by eradicating road markings, traffic controls, and physical boundaries. These streets are preferred for their capacity to amplify the *place* function aspect of urban spaces, fostering vibrant social and commercial activities. They encourage walking and bicycling and cultivate livable communities that nurture increased social interactions among residents and road users alike. Despite numerous guidelines illustrating the design principles of shared spaces, a significant gap exists in delineating the selection criteria for potential shared space streets. This void in knowledge is particularly pertinent for emerging adopters, such as Malaysia, seeking guidance in identifying suitable sites for implementation. This study aims to bridge this gap by presenting a comprehensive shared space selection framework utilizing the Analytic Hierarchy Process (AHP). The framework establishes selection criteria and assessment rubrics to evaluate candidate sites systematically. The proposed framework is applied in a case study within the Klang Valley, Malaysia, to demonstrate its efficacy in selecting the most appropriate site from a pool of five potential locations. The results underscore the feasibility of the proposed framework, offering a structured approach to facilitate shared space site selection and implementation.

Keywords: Shared space street, Multi Criteria Decision Making, Analytic Hierarchy Process

# IMPLEMENTING DIGITAL TWIN SOLUTIONS INTO SMART CITY INFRASTRUCTURE MANAGEMENT: CASE STUDY OF NIDA SMART CAMPUS IN THAILAND

A. Sarawut JANSUWAN [a*]

[a] *Graduate School of Applied Statistics, National Institute of Development Administration (Nida), Bangkok, Thailand*

[*] *Email: sarawut@as.nida.ac.th (Corresponding author)*

The rapid advancement of Internet of Things (IoT) and digital twin technologies has opened new avenues for revolutionizing infrastructure and asset management in smart city environments. The integration of Internet of Things (IoT) technology into smart city management represents a paradigm shift in urban connectivity, governance and infrastructure optimization. This paper has demonstrated the journey from conceptualization to practical implementation of digital twin solutions in optimizing smart campus infrastructure management. The case study of NIDA smart campus in Thailand is outlined. The study explores the specific difficulties encountered in managing campus infrastructure and the advantages of incorporating digital twins into their operation to address the concerns present on campus. The smart campus development aligns with the smart city's dimensions including: 1) smart mobility, 2) smart energy, 3) smart building, 4) smart community, 5) smart environment, 6) smart economy, 7) smart governance, and 8) smart innovation. The implementation process involves several stages, including data acquisition, model creation using GIS, simulation, and real-time monitoring. Practical considerations such as data integration, interoperability, scalability, and cybersecurity are thoroughly examined to ensure the seamless integration of digital twins into existing campus infrastructure systems. The extensive IoT data collected from diverse sensors is analysed to comprehend the efficiency of facility administration and identify areas for enhancement. Practitioners can benefit from the expertise and lessons obtained in real-world practice, which can have practical consequences for campus infrastructure and asset management and be expanded to city levels.

Keywords: Digital Twin Solutions, Smart City, Smart Campus, Smart Mobility, Internet of Things (IoT)

SESSION D3: Urban Transport Accessibility and Equity

# REAPPRAISAL OF TRANSIT-ORIENTED DEVELOPMENT

A. Roger VICKERMAN [a,b*]

[a] *School of Economics, University of Kent, Canterbury, UK*

[b] *Department of Civil and Environmental Engineering, Imperial College London, UK*

**Email: r.w.vickerman@kent.ac.uk; r.vickerman@imperial.ac.uk (Corresponding author)*

Transit-Oriented Development (TOD) is an important bridge between land-use planning and transportation. However, in most applications one or the other element is seen as given with either land-use planning and development responding to available transportation facilities or new transit services developed in response to given employment or residential facilities. Transport appraisal typically focuses on the behaviour of, and benefits for, the transport user, with the possible addition of wider economic impacts to reflect economic effects beyond the user. The focus is also on developments that generate work-related journeys. The way in which transport demand is changing in a post-Covid, net zero world with changing work patterns and a greater focus on non-work-related travel requires a reassessment of TOD. Development opportunities for leisure activities create travel for both users and employees but with different characteristics comparing individual journeys with family or group travel. The acceleration of inter-city transport, through for example high-speed rail, may change the focus of TOD with an emphasis on the process of agglomeration in a world of connected and competing cities. Appraisal for TOD needs, therefore, to reflect a general equilibrium view where transport also affects the supply side and non-user benefits. In this paper we review methods of appraisal for TOD in this changing world and outline a more comprehensive and inclusive approach that addresses the uneven impact of investments across different communities and individuals taking account of all sources of inequality in accessibility.

Keywords: Transit-oriented development; wider economic impacts; general equilibrium; accessibility and equity; connecting cities

# UNDERSTANDING URBAN SPATIAL STRUCTURE THROUGH THE LENS OF MULTIPLE MODAL ACCESSIBILITY

A. Jie HUANG[a*], B. Meicheng XIONG [b] and C. Jiaoe WANG [a]
[a] *Key Laboratory of Regional Sustainable Development Modeling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China*
[b] *Department of Geography, Environment and Society, University of Minnesota, USA*
**Email: huangjie@igsnrr.ac.cn (Corresponding author)*

In contrast to most previous studies that investigated the accessibility pattern of a single transport mode, this study proposes a research framework based on the concept of modal accessibility gap (MAG). This framework uses cumulative accessibility measurements, spatial clustering methods with spatial constraints, and online map tools. These methods were employed in the urban spatial structure identification of Kunming, a major city in Southwest China. The findings can be summarized as follows: First, there are obvious spatial disparities in accessibility between motorized and non-motorized transport modes, which emphasize the necessity of understanding urban structures with multiple modal accessibility. Second, combining the accessibility of the four common modes (driving, public transport, walking, and cycling) with spatial constraints is beneficial for maintaining spatial continuity. In addition, some substructures can be better depicted than the urban structure detection within a single mode. Thus, introducing non-motorized transport modes into the MAG analysis is helpful for the urban planning of green mobility, healthy lifestyles, and human well-being.

Keywords: modal accessibility gap; transport modes; urban spatial structure; spatial clustering method

# ANALYZING INCOME-BASED INEQUALITY IN TRANSIT NODAL ACCESSIBILITY

A. Dong LIU [a,b,c] , B. Mei-Po KWAN [d,e*], C. Jianwei HUANG [e], D. Zihan KAN [e],
E. Yimeng SONG [f] and F. Xuefeng LI [g]

[a] *Human Environments Analysis Laboratory, The University of Western Ontario, Social Sciences Centre, 1151 Richmond Street, London, ON N6A 5C2, Canada*

[b] *Department of Geography and Environment, The University of Western Ontario, Social Sciences Centre, 1151 Richmond Street, London, ON N6A 5C2, Canada*

[c] *Department of Geography and Geographic Information Science, University of Illinois at Urbana-Champaign, Natural History Building, 1301 W Green Street, Urbana, IL 61801, USA*

[d] *Department of Geography and Resource Management, The Chinese University of Hong Kong, Shatin, Hong Kong*

[e] *Institute of Space and Earth Information Science, The Chinese University of Hong Kong, Shatin, Hong Kong*

[f] *Department of Land Surveying and Geo-Informatics and Smart Cities Research Institute, The Hong Kong Polytechnic University, Hung Hom, Hong Kong*

[g] *College of Automobile and Traffic Engineering, Nanjing Forestry University, Nanjing, Jiangsu 210037, China*

**Email: mpk654@gmail.com (Corresponding author)*

Public transit is the main travel mode for residents in major urban areas to access different socioeconomic resources. Nodal accessibility can be used to measure the level of transit-based connectivity for residents from one neighborhood to socioeconomic resources in other neighborhoods. While many existing studies have measured the spatial inequality in nodal accessibility, few have comprehensively explored income-based inequality in nodal accessibility, especially between the richest and poorest of the population. This study examines the income-based inequality in nodal accessibility in Hong Kong using both the Gini coefficient and the 20:20 ratio. Our study shows that except Kowloon City, Sai Kung and Kwai Tsing, all districts suffer from some degree of inequality either among its middle-income residents or between its richest and poorest 20% residents. Besides, among all 18 districts, the poorest 20% living in Islands District not only have the lowest median monthly household income but also are most disadvantaged in terms of nodal accessibility compared to the richest 20% living in the same district. Overall, the results indicate that the Gini coefficient alone is inadequate in revealing the inequality between the richest and poorest of the population, while the 20:20 ratio can complement such inadequacy. Our results can inform policymakers to develop measures to alleviate income-based inequality in nodal accessibility.

Keywords: Nodal accessibility Public transit Gini coefficient 20:20 ratio Hong Kong

# ARE SINGAPORE'S NEW TOWNS SELF-CONTAINED? – AN EXAMINATION BASED ON THE POST-COVID PUBLIC TRANSPORT SMARTCARD DATA

A. Yuting HOU [a*], B. Jieming ZHENG [a], C. Xize WANG [b] and D. Sylvia Y. HE [c]
[a] *Department of Building and Real Estate,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
[b] *Department of Real Estate, National University of Singapore, Singapore*
[c] *Department of Geography, The Chinese University of Hong Kong, Hong Kong SAR, China*
[*] *Email: yuting.hou@polyu.edu.hk (Corresponding author)*

Self-containment is a major planning objective for new town development. This study assesses the self-containment levels of Singapore's new towns and planned centers by analyzing the geography of commuting and non-commuting passenger flows among selected regional centers, sub-regional centers and town centers. Specifically, we utilize the public transport smart card data from the Land Transport Authority – Singapore's transit authority – in 2021-2022, and explore two sets of questions: 1) are the service sheds of new towns/planned centers for commuting and non-commuting travel purposes locally confined or city-wide? 2) how does the spatial extent of new towns'/centers' service sheds vary by the regional-, sub-regional- and town-center ranks? The findings imply whether and to what extent the new towns/centers in Singapore are "self-contained" or economically interdependent with each other, and provide insights for Singapore's future transport and land use planning.

Keywords: New town, commuting trips, non-commuting trips, urban form, polycentricity, smartcard data

# "TRANSFERRED BIAS" UNCOVERS THE BALANCE BETWEEN THE DEVELOPMENT OF PHYSICAL AND SOCIO-ECONOMIC ENVIRONMENTS OF CITIES

A. Ce HOU [a, b], B. Fan ZHANG [a*], C. Yuhao KANG [c], D. Song GAO [d], E. Fa´bio DUARTE [e], F. Yong LI [a, b] and G. Sen LI [b*]

[a] *Institute of Remote Sensing and Geographical Information System, School of Earth and Space Sciences, Peking University, Beijing, China*

[b] *Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology, Hong Kong*

[c] *Department of Geography and the Environment, University of Texas at Austin, United States*

[d] *Geospatial Data Science Lab, Department of Geography, University of Wisconsin-Madison, United States*

[e] *Senseable City Lab, Massachusetts Institute of Technology, United States*

[*] *Email: fanzhanggis@pku.edu.cn; cesli@ust.hk (Corresponding authors)*

Evaluating the balance of developments between a city's physical and socio-economic environments is crucial for creating sustainable and livable urban spaces. While they may appear contradictory, they jointly support the comprehensive sustainable urban development strategy. Traditional methods usually focus on assessing this balance in urban development from a specific perspective, such as how neighborhood greenery shapes real estate value. Yet, they fall short of delivering a holistic balance assessment in the development of the physical and socio-economic dimensions. To fill this gap, this study introduces a research framework that measures this balance through house prices based on "transferred bias." We recognize that both physical and socio-economic environments shape house prices. The framework first constructs a series of deep learning models, using street view images to estimate house prices for each city, capturing the relationship between neighborhood appearance and house price. Secondly, by leveraging transfer inference, we introduce neighborhood appearance from one city into the model trained from another city. This process identifies the "transferred bias," which is the disparity between inaccurate inference resulting from a mismatched neighborhood appearance and the trained model. Through "transferred bias," we can quantify the differences in physical and socio-economic environments across cities and evaluate the urban balances of these two environments. The results show that the "transferred bias" effectively quantifies the disparities among cities in physical and socio-economic environments, thereby facilitating further investigation into the urban equilibrium between these two environments.

Keywords: sustainable urban development, transfer learning, street view image, deep learning

SESSION D4: On-Demand Delivery Service Optimization

# TO GRAB OR NOT? REVEALING DETERMINANTS OF DRIVERS' WILLINGNESS TO GRAB ORDERS IN ON-DEMAND RIDE SERVICES

A. Taijie CHEN [a*], B. Jian LIANG [a], C. Ya ZHAO [b*] and D. Jintao KE [a*]
[a] *Department of Civil Engineering, The University of Hong Kong, China*
[b] *Department of Urban Planning and Design, The University of Hong Kong, Hong Kong, China*
**Email: ctj21@connect.hku.hk; zhaoya95@connect.hku.hk; kejintao@hku.hk*
*(Corresponding author)*

The widespread use of smartphones has sharply accelerated the development of on-demand ride services, including e-hailing taxi and ride-hailing services. The success of these services depends on efficient mechanisms for matching passengers with drivers, which can be mainly categorized into broadcasting and dispatching modes. In the dispatching mode, drivers are directly assigned by the platform to specific passengers, whereas in the broadcasting mode, drivers have the freedom to select an order from a pool of passenger requests broadcast by the platform. Although the dispatching mode has been extensively studied in the literature, the broadcasting mode has received little attention. In particular, the willingness of drivers to grab orders is crucial to the success of the broadcasting system, as low willingness to grab orders can lead to decreased system efficiency, prolonged passenger waiting times, and reduced passenger satisfaction levels. Therefore, it is of great importance to investigate the factors that influence drivers' willingness to grab orders in the broadcasting mode. This paper makes one of the first attempts to explore drivers' order-grabbing behaviors in on-demand ride services by empirically analyzing an e-hailing taxi dataset in Hong Kong. Our research uncovers a nonlinear relationship between drivers' willingness to grab orders (WTG) broadcast by the e-hailing taxi platform and orders' delivery distances, where WTG first increases and then decreases with delivery distance. Our empirical findings also reveal the relationship between WTG and other trip-level and zone-level factors, such as observing that WTG decreases with pickup distance and origins' road network density. These findings offer valuable managerial insights that can assist on-demand ride service platforms in designing more effective order-broadcasting strategies and provide policy suggestions for policymakers to develop more sustainable and equitable urban transportation systems.

Keywords: Autonomous Mobility-on-Demand systems; vehicle reposition; reinforcement learning; Monte Carlo Tree Search.

# ORDER ASSIGNMENT FOR ON-DEMAND FOOD DELIVERY SERVICE CONSIDERING DRIVER BEHAVIOR

A. Jian LIANG [a] and B. Jintao Ke [b*]
[a] *Department of Civil Engineering, The University of Hong Kong, Hong Kong SAR, China*
[b] *Department of Civil Engineering, The University of Hong Kong, Hong Kong SAR, China*
**Email: kejintao@hku.hk (Corresponding author)*

The rapid growth of the food delivery industry has heightened customer expectations and intensified competition among platforms. In this context, efficiently assigning orders to food delivery drivers has become a critical operational challenge for platforms seeking a competitive edge. While order assignment algorithms have been extensively studied in recent years, existing optimization algorithms focus on enhancing overall operational efficiency and often ignore driver behavioral deviations. Drawing on real-world operational data from a food delivery service provider, we observe that substantial orders assigned to drivers are subsequently rejected by them. To address this issue, we propose a novel framework that integrates a driver behavior estimator with order assignment optimization. This integration allows us to adjust the assignment decisions based on the preferences and behaviors of individual drivers. Through extensive experiments conducted on real-world datasets, we demonstrate the effectiveness of the proposed order-assignment framework. Our findings also underscore the importance of leveraging operational data to learn and adapt to driver behavior in real-time order assignments.

Keywords: order assignment, on-demand service, driver behavior, simulation optimization

# CROWDSHIPPING PLATFORM AS AN INTERMEDIARY: AUCTION-BASED MECHANISM DESIGN FOR ORDER ALLOCATION AND PAYMENT SCHEMES

A. Qingyang LI [a*] and B. Fangni ZHANG [a*]
[a] *Department of Industrial and Manufacturing Systems Engineering, The University of Hong Kong, Hong Kong SAR, China*
[*] *Email: qyli2001@connect.hku.hk, fnzhang@hku.hk (Corresponding authors)*

Crowdshipping has emerged as a novel service paradigm to move parcels by leveraging the latent capacity of traveling "crowd" from enormous traveling trips in the transportation system. This work investigates the order allocation and payment schemes for a crowdshipping platform through the lens of auction mechanisms. The crowdshipping platform is designed as an intermediary sitting between orders and travelers, which seeks the services provided by either the crowd carrier or the outsourced dedicated carrier. To ensure the sustainability of such platforms, the key challenge lies in matching orders to crowd carriers so that the payments are differentiated, crowdshipping platforms gain nonnegative profits and system efficiency is achieved. However, heterogeneity among individual crowd carriers exists and their preferences are not readily available. This motivates us to devise auction mechanisms for order allocation and payment of the crowdshipping platform. In the crowdshipping system, crowd carriers report their trip information (e.g., origin, destination, and available routes) to the platform and are recommended for some orders for each route. Then travelers select their intended orders and submit route-based bids based on the detour costs. The platform takes carriers' strategic behavior into account and applies the classic VCG-like payment scheme to ensure incentive compatibility, individual rationality, and system efficiency. For the sake of computational efficiency, we design a greedy mechanism which retains most of the economic properties and provides an approximation guarantee. The profit gained by the platform can be lower bounded in both mechanisms. Extensive numerical experiments are conducted to test the performance of the proposed mechanisms.

Keywords: Crowd-shipping, Matching, Pricing, Auction, Mechanism design

# MODELING AND OPTIMIZATION OF ON-DEMAND DELIVERY WORKFORCE CAPACITY WITH ENDOGENOUS SERVICE INTENSITY

A. Ting SUN [a], B. Yipu NIU [a], C. Rui XUE [a], D. Jing-peng WANG [b*] and E. Peng LIU [a*]

[a] *School of Economics and Management, Beihang University, Beijing*

[b] *School of Management, Shandong University, Jinan*

[*] *Email: wangjingpeng@sdu.edu.cn; liu@buaa.edu.cn (Corresponding authors)*

With the rapid growth of the instant delivery industry, balancing the dual demands of delivery efficiency and the labor rights of delivery riders has emerged as a pressing concern. This study aims to propose an on-demand delivery workforce capacity allocation model that incorporates endogenous service intensity. Using user equilibrium theory, we first propose a time-expanded network with formulations and algorithms. This network captures how full-time riders choose their work hours and maps the spatial and temporal distribution of instant delivery tasks. The model also includes crowd-sourced riders and analyzes the specific contributions of different capacity types within the instant delivery service supply chain. To balance the interests of the platform and various stakeholders, such as customers, merchants, and delivery riders, we utilize a bi-level programming framework. The lower-level model prioritizes achieving an equilibrium allocation of capacity, while the upper-level model handles the platform's decisions related to time-varying wage rates. The analytical and numerical results demonstrate that implementing refined wage rate settings on instant delivery platforms can significantly reduce overall costs. This study offers a scientific and systematic framework for the sustainable development and capacity management in the instant delivery industry.

Keywords: instant delivery, time-expanded network, user equilibrium, wage-rate, bi-level optimization

# WILL PROVIDING RETURN-FREIGHT-INSURANCES DO MORE GOOD THAN HARM TO DUAL-CHANNEL E-COMMERCE RETAILERS?

A. Jiaxin LIN [a*], B. Tsan-Ming CHOI [b] and C. Yong-Hong KUO [a*]

[a] *Department of Industrial and Manufacturing Systems Engineering, The University of Hong Kong, Hong Kong SAR, China*

[b] *Centre for Supply Chain Research, University of Liverpool Management School, Chatham Building, Liverpool L69 7ZH, the United Kingdom*

* *Email: linjx@connect.hku.hk; yhkuo@hku.hk (Corresponding authors)*

Today, e-commerce retailers commonly operate in a dual-channel mode. Return freight insurance (RFI) is an emerging measure to resolve online shopping disputes with product returns. If a consumer returns an insured product, the insurance company will compensate the consumer for the return-freight fee. In practice, we observe that some dual-channel e-commerce retailers offer RFI to consumers, while others do not. We build consumer-utility-based analytical models to study the retailer's optimal pricing decisions and values of RFI. In the basic models, the proportions of store-type consumers and online-type consumers are exogenously given; we examine three cases, namely Case N (RFIs are not provided), Case R (retailer purchases RFI for consumers), and Case C (consumers pay for RFI). Comparing these three cases, we uncover that the retailer who purchases RFI for consumers does not necessarily charge a higher price. We show that if the RFI premium is sufficiently (moderately) low, it is more beneficial for consumers (the retailer) to pay for the RFI. We analytically prove that (i) when the product's salvage value is polarized or the return freight cost is low, using RFI can help increase consumer surplus (CS), (ii) when the salvage value is sufficiently high, the social welfare (SW) with RFI is higher than the case without RFI.

Keywords: Supply chain management; e-commerce; pricing; return freight insurance; dual channel.

SESSION D5: Pedestrian-Vehicle Interaction Studies

# EFFECT OF VEHICLE VELOCITY ON PEDESTRIAN MOVEMENT AT CROSSWALKS: A CASE STUDY USING EMPIRICAL DATA

A. Tao LI [a], B. Zhanbo SUN [a*], C. Hongliang DING [b], D. Ruiqi WANG [a],
E. Zhijian FU [a] and F. Ang JI [b]
[a] *School of Transportation and Logistics,*
*Southwest Jiaotong University, Chengdu, Sichuan, China*
[b] *Institute of Smart City and Intelligent Transportation,*
*Southwest Jiaotong University, Chengdu, Sichuan, China*
**Email: zhanbo.sun@home.swjtu.edu.cn (Corresponding authors)*

The paper seeks to examine the influence of vehicle speeds on pedestrian movement at crosswalks through controlled experiments conducted on real roads. Pedestrian behaviors including crossing speed, movement deviation, and stress level were considered in the study. The findings reveal that pedestrian's position offset, head deviation angle/frequency increase at higher vehicle speeds. Specifically, the likelihood of a 40° pedestrian head deviation angle is significantly higher when vehicle speed exceeds 30 km/h. In addition, when vehicle speed is in the range of 30-50km/h, frequent occurrence of standstill and speed fluctuations of pedestrians are observed. The results also indicate that vehicle speed significantly impacts the walking stability and stress level of pedestrians while crossing the road. Findings from this study have implications for enhancing pedestrian safety, such as crossing infrastructure design, traffic signal control, safe driving training, and improving autonomous driving systems' ability to understand pedestrian behavior.

Keywords: Pedestrian-vehicle interaction; pedestrian movement; vehicle speed; stress level

# ANALYSIS OF PEDESTRIAN CROSSING BEHAVIORS AT UNSIGNALIZED CROSSWALKS ON FOUR-LANE BIDIRECTIONAL ROADS

A. Masahiro YOSHIMURA [a*], B. Satoru KOBAYAKAWA [b]
and C. Noriyasu TSUMITA [b]
[a] *Graduate School of Science and Technology, Nihon University, Japan*
[b] *Department of Transportation System Engineering, Nihon University, Japan*
**Email: csma23001@g.nihon-u.ac.jp (Corresponding author)*

Understanding pedestrian crossing behaviors at unsignalized crosswalks on multi-lane roads is crucial for improving urban traffic safety. This study investigates pedestrian crossing behaviors at unsignalized crosswalks on multi-lane roads in Chiba, Japan. This study aims to understand how pedestrians cross the road at unsignalized crosswalks. The study specifically clarifies the influence of gender, age, crossing direction, and gap acceptance on these behaviors. To examine the pedestrian crossing behaviors, video observations for capturing pedestrian and vehicular movements were conducted over two weekdays. These behaviors were categorized into four types: single-stage crossing, two-stage crossing, rolling gap crossing, and stop-before crossing. Based on the video analysis, significant variations in crossing behaviors by gender and crossing direction were observed. Males tend to choose rolling gap crossing more often, whereas females predominantly choose stop-before crossing, indicating a higher preference for safety. Additionally, pedestrians crossing from the near side (those visible to drivers on the left side) exhibited a higher tendency to choose stop-before crossing. The study also utilized binary logistic regression analysis to analyze factors influencing the choice between rolling gap crossing and stop-before crossing. This analysis has clarified that significant variables included gender and crossing direction, while distance gaps were not significant, suggesting the need for future research using time gaps. This research underscores the importance of understanding pedestrian crossing behaviors at unsignalized crosswalks on multi-lane roads. It highlights the necessity to explore safety measures beyond crosswalk infrastructure to mitigate risky crossing behaviors on urban crosswalks.

Keywords: pedestrian crossing behaviors, unsignalized crosswalk, multi-lane road, traffic safety

# UNDERSTANDING PEDESTRIAN CROSSING BEHAVIOUR USING EXTENDED THEORY OF PLANNED BEHAVIOUR: A CASE OF HYDERABAD, INDIA

A. Anam HYDER [a] and B. Saladi. S.v. SUBBARAO [a*]

[a] *Department of Civil Engineering, Mahindra University, Hyderabad Telangana, India*

[*] *Email: saladi.subbarao@mahindrauniversity.edu.in (Corresponding author)*

Pedestrian safety is a rising problem across the world. According to the Ministry of Road Transport and Highways (MoRTH), 25,858 pedestrians were killed in India in 2019, which is 17% of the total road fatalities. Though several studies have been reported in the literature for understanding pedestrian crossing behaviour in heterogeneous traffic conditions, limited studies have been reported at un-signalized intersections where pedestrian-vehicle conflicts are prevalent. One of the most practical theories in the social cognitive field is the Theory of Planned Behaviour (TPB). This theory follows a socio-psychological approach to evaluate pedestrian crossing behaviour. The present study, extends the TPB approach by incorporating additional factors like perceived risks, conformity tendency, descriptive norms, personal norms, etc. for understanding pedestrian behavioural intention towards crosswalks. In this context, a questionnaire has been designed and it was administered to collect 1500 samples from six un-signalized in Hyderabad Metropolitan Region, India. Reliability and validity of the data have been examined with the appropriate analysis techniques. Further, a structural equation model has been developed to understand pedestrian behavioural intention to cross the road, which in turn explains the pedestrian crossing behaviour. From the model results, it has been observed that pedestrian attitudes, subjective norms, and personal norms are more influencing factors for predicting behavioural intention. The study findings will be useful to policymakers and urban planners can craft more effective strategies to foster safer pedestrian experiences.

Keywords: Pedestrian behaviour, Theory of Planned Behaviour(TPB), Un-signalised intersections, Structural Equation Modelling(SEM)

# MEASURING PEDESTRIAN PERCEPTION AND BEHAVIOR ALONG AN URBAN STREET DURING THE DAYTIME AND NIGHTTIME THROUGH THE USE OF EYE-TRACKING TECHNOLOGY

A. Carreen de CÁRDENAS [a], B. Afrida RAIDA [a], C. Arman HOSSEINI [b], D. Eilise O'CONNOR [b], E. Arsalan HEYDARIAN [a], F. Andrew MONDSCHEIN [b] and G. T. Donna CHEN [a*]
[a] *Department of Civil and Environmental Engineering, University of Virginia, Charlottesville, VA, 22902*
[b] *Department of Systems and Information Engineering, University of Virginia, Charlottesville, VA, 22902*
[*] *Email: tdchen@virginia.edu (Corresponding author)*

Pedestrians are some of the most vulnerable road users and pedestrian fatalities have been increasing over the last 15 years, particularly at night. In order to create safer infrastructure for pedestrians, it is imperative to understand how pedestrian perception and behavior varies between the daytime and nighttime. Understanding pedestrian behaviors, preferences, and perception of the built environment is essential for creating spaces that promote more active modes of transportation. This study employs mobile eye-tracking glasses and stated preferences surveys to examine differences in pedestrian attention and perceptions of comfort and safety along an urban corridor in Charlottesville, VA, USA during the daytime and nighttime. The analysis of the gaze data uses an urban typology framework which allows for quantitative differentiation in pedestrian's attention to various urban stimuli, such as transportation elements, built infrastructure, people, and nature. The results indicate that at night, participants paid more attention to vehicles, lighted crossing infrastructure, and lighting features, while attention on unlit transportation infrastructure and nature decreased. Findings from the study also suggest that there is a connection between lighting levels and perception of safety. Locations with the lowest lighting levels along the route were frequently identified by participants as locations they felt the most unsafe at night. The study proposes a comprehensive model of measuring attention, perception, and cognition, and sets the groundwork for future research on linkages between the experiential dimensions of streets, human well-being, and pedestrian behaviors.

Keywords: pedestrians, perceived safety, eyetracking

# TOWARDS DEVELOPING SOCIALLY-COMPLIANT AUTOMATED VEHICLES: STATE OF THE ART, EXPERTS EXPECTATIONS, AND A CONCEPTUAL FRAMEWORK

*A. Yongqi DONG [a,b*], B. Bart Van AREM [a] and C. Haneen FARAH [a]*
[a] *Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, The Netherlands*
[b] *Institute of Highway Engineering, RWTH Aachen University, Aachen, Germany*
**Email: yongqi.dong@rwth-aachen.de (Corresponding author)*

Automated vehicles (AVs) hold promise for revolutionizing transportation by improving road safety, traffic efficiency, and overall mobility. Despite the steady advancement in high-level automated vehicles (AVs) in recent years, the complete deployment of fully automated vehicles remains a gradual process. This transition to full automation entails a period of mixed traffic, where AVs of varying automation levels coexist with human-driven vehicles (HDVs). Making AVs socially compliant and understood by human drivers is expected to improve the safety and efficiency of mixed traffic. Thus, ensuring their social acceptance and compatibility with HDVs is crucial for their successful and seamless integration into mixed traffic systems. However, research in this critical area of socially compliant AV development remains sparse. This study carries out the first scoping review to assess the current state of the art in developing socially compliant AVs, identifying key concepts, methodological approaches, and research gaps. A preliminary expert interview was also conducted to identify critical issues and research expectations towards socially compliant AV. Based on the scoping review and expert interview input, a conceptual framework was designed for the development of socially compliant AVs. The proposed conceptual framework was evaluated through an online questionnaire survey with researchers, technicians, policymakers, and other relevant professionals globally. The survey results provide valuable validation and insights, affirming the significance of the proposed framework in tackling the challenges of integrating AVs into mixed-traffic environments. Additionally, future research perspectives and suggestions for future enhancements are elicited, contributing to the evolution of AV technology.

Keywords: Automated vehicles, Socially-compliant driving, Mixed traffic, Conceptual model, Scoping review

SESSION D6: Drone Integration in Transportation

# DRONE-TRANSIT COOPERATION FOR LAST-MILE DELIVERY: A MAXIMAL COVERING LOCATION PROBLEM APPROACH

A. S. JAITA [a], B. S. KITTHAMKESORN [a*] and C. S. OPASANON [b]

[a] *Department of Civil Engineering, Chiang Mai University, 50200, Thailand*

[b] *Department of International Business, Logistics and Transport, Faculty of Commerce, and Accountancy, Thammasat University, Bangkok 10200, Thailand*

**Email: opasanon@gmail.com (Corresponding author)*

Driven by e-commerce growth, the need for efficient and convenient last-mile delivery solutions has intensified, prompting exploration of innovative technologies like drones. This study presents a maximal covering location problem for integrating drone deliveries with public transportation, leveraging the latter as mobile charging stations to extend drone range. The proposed mixed-integer linear programming (MILP) optimizes the warehouse location and the potential drone deployment points along transit lines for maximizing the number of demands served. Numerical examples demonstrate that strategically locating the warehouse near the transit system for drone deployment significantly extends delivery range. Battery technology is identified as a key factor influencing the warehouse location and the subsequent effectiveness of this integrated delivery approach.

Keywords: Drone-transit, maximal covering, mixed-integer linear programming, last-mile delivery

# MODELLING THE ELECTRIC VEHICLE ROUTING PROBLEM WITH DRONES UNDER WIRELESS CHARGING LANES PROVISION

A. Shishu SHEN [a], B. Xiang ZHANG [a*], C. Ning MA [a] and D. Yan HUO [a]

[a] *College of Transportation Engineering, Dalian Maritime University, Liaoning, China*

**Email: xiangzhang_dlmu@163.com (Corresponding author)*

In this work, we are interested in studying the Electric Vehicle Routing Problem with Drones (EVRPD). Unlike previous studies, this research integrates wireless charging lanes (WCL) into the network to address the limited range and long charging time of EVs. This paper aims to design feasible routes, optimize drone operations, and determine recharge options en route, ensuring that all customers are served while minimizing delivery costs. We propose modeling the EVRPD as a Mixed-Integer Linear Program (MILP). The objective function focuses on the cost fluctuation associated with EV charging through WCL during transportation. Additionally, we investigate the impact of varying WCL deployment on vehicle fleet configuration, remaining power, and overall delivery costs within the mathematical model. The optimization problem is solved using a branch-and-price algorithm to obtain an exact solution. Finally, extensive computational experiments were conducted to evaluate the solution quality and demonstrate the efficacy of the model. Numerical results indicate that EVs equipped with drones within the WCL road network for collaborative delivery can significantly reduce delivery costs compared to a fleet without WCL. Moreover, the proposed MILP model, alongside the branch-and-price approach, contributes significantly to solving the EVRPD effectively.

Keywords: Vehicle routing problem with drones; Electric vehicle; Wireless charging lanes; Dynamic charging; Branch-and-price

**IMPACT OF PERCEIVED SERVICE QUALITY OF DRONE DELIVERY SERVICE ON BEHAVIORAL INTENTION TO USE**

A. Xinyu CHEN [a*] and B. Sunghoon JANG [a*]

[a] *Department of Civil and Environmental Engineering,*

*The Hong Kong Polytechnic University, Hong Kong SAR, China*

[*] *Email: xinyu1.chen@connect.polyu.hk; sunghoon.jang@polyu.edu.hk (Corresponding author)*

The drone delivery service has received a lot of attention in recent years as an alternative to traditional delivery services. In line with the emergence of drone delivery services, there have been significant efforts by global companies towards the commercialization of drone delivery services. This will lead to a major shift in the market share of transport and logistics delivery services. In this background, the aim of this study is to gain an in-depth understanding of consumers' intentions to use drone delivery services, focusing on the perceived service quality. A web-based survey collected the information necessary to measure different dimensions of perceived service quality of drone delivery services and consumers' behavioral intention to use. The generalized ordered logit model is estimated to evaluate hypothetical relations between several latent variables. Our results reveal that there are significant differences in terms of gender and age: The perceived service quality of the drone delivery service has a stronger effect on the intention to use it among females and the elderly. Also, we found that the perceived complexity to use and functionality concerns are the most significant factors affecting the intention to use. Our results are useful for transportation and logistics planners to predict future market changes. Moreover, the results suggest how to improve the service quality to increase the adoption of drone delivery services.

Keywords: Drone delivery service, Consumers' behavioral intentions to use, Generalized ordered logit model

# A BRANCH-PRICE-AND-BENDERS-CUT APPROACH FOR OPTIMIZING THE SCHEDULING OF URBAN SUBWAY INSPECTION SERVICES USING UAVS

A. Bolong ZHOU [a*], B. Wenjia ZENG [a*], C. Wei LIU [b*] and D. Hai YANG [a*]

[a] *Department of Civil and Environmental Engineering,*
*The Hong Kong University of Science and Technology, Hong Kong, China*
[b] *Department of Aeronautical and Aviation Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
[*] *Email: bolong.zhou@connect.ust.hk; wenjia.zeng@connect.ust.hk; wei.w.liu@polyu.edu.hk; cehyang@ust.hk (Corresponding authors)*

The periodic inspection and maintenance of subway facilities are essential for ensuring passenger safety. However, the current manual inspection practices conducted by expert engineers are time-consuming, costly, and pose risks to workers. Unmanned aerial vehicles (UAVs) offer a promising solution for automatically inspecting subway facilities. This paper investigates an operational-level synchronized optimization problem, aiming to determine an optimal inspection timetable while simultaneously optimizing working schedules for both human teams and UAVs. Demand heterogeneity is taken into account since the variety of facilities and equipment in subway tunnels may have different required inspection cycles. A compact Mixed-Integer Linear Program (MILP) model is developed to solve this NP-hard problem. We propose an enumeration-based reformulation and develop an exact algorithm that combines Benders decomposition and Dantzig-Wolfe decomposition within a branch-and-price framework to solve the MILP model efficiently. The approach is strengthened by implementing several acceleration strategies. Extensive numerical experiments have been carried out. The results show that our proposed optimization model and algorithms can find the optimal solution for real-world scale instances, resulting in cost savings and improved efficiency. Furthermore, we highlight the benefits of integrated optimization by comparing our solution approach with a sequential method that addresses inspection timetables and working schedules separately.

Keywords: UAV, inspection timetable, working schedule, synchronized optimization, Benders decomposition, branch-and-price

## SESSION E1: Optimization for Connected Autonomous Vehicles

# COORDINATED DISTRIBUTED TRAJECTORY PLANNING FOR CONNECTED AND AUTONOMOUS VEHICLES AT EXPRESSWAY BOTTLENECKS UNDER MIXED TRAFFIC ENVIRONMENT

A. Jingmin LIN [a], B. Chunhui YU [a*], C. Benwei CHEN [a] and D. Wanjing MA [a]

[a] *The Key Laboratory of Road and Traffic Engineering of the Ministry of Education, Tongji University, Shanghai, China*

**Email: hughyu90@tongji.edu.cn (Corresponding author)*

The mixed traffic consisting of connected and autonomous vehicles (CAVs) and human-driven vehicles (HVs) has emerged and brings new challenges to trajectory planning for CAVs, for example, at expressway bottlenecks. Existing studies either focus on ego-efficient trajectory planning for individual vehicles in a decentralized way or system-optimal trajectory planning for all vehicles in a centralized way. The challenge remains to balance computational efficiency and system optimality. This study proposes a coordinated distributed trajectory planning model for CAVs at an expressway bottleneck with lane drop under the mixed traffic environment. A mixed-integer linear program model is formulated to optimize the acceleration profile and lane choices of an individual CAV for delay minimization and trajectory smoothness. The influence range of a CAV is defined. When the distributed optimized trajectories of CAVs have conflicts within the overlap of their influence ranges, the planned CAV trajectories are coordinated by iteratively re-optimization considering conflicting CAV trajectories in the safety constraints. Numerical studies validate that the proposed coordinated distributed trajectory planning model can balance the system benefits and computational efficiency compared to the centralized control and uncoordinated distributed control.

Keywords: coordinated distributed trajectory planning; mixed traffic; connected and autonomous vehicle; expressway bottleneck

# ROBUST STRING-STABLE CAR-FOLLOWING CONTROL FOR CONNECTED AND AUTOMATED VEHICLES UNDER MULTIPLE-SOURCE INFORMATION DELAYS

A. Yuan ZHENG [a*], B. Lue FANG [b], C. Shen LI [c*], D. Yu ZHANG [d], E. Lu BAI [a] and F. Bin RAN [a]

[a] *Jiangsu Province Collaborative Innovation Center of Modern Urban Traffic Technologies, Southeast University, Nanjing 211189, China*

[b] *School of Engineering, Brown University, 69 Brown Street, Providence, RI 02912-9091, U.S.*

[c] *Department of Civil Engineering, Tsinghua University, Beijing 100084, China*

[d] *Autonomous Delivery Center, Beijing Sankuai Technology Co., Ltd., 2 Lize East Street, Beijing 100102, China*

**Email: 101013486@seu.edu.cn; sli299@tsinghua.edu.cn (Corresponding authors)*

Robust string-stable control for connected and automated vehicles (CAVs) is significant for improving the operational performance of vehicle platooning thanks to advanced sensing and Vehicle-to-Vehicle (V2V) communication technologies. However, there are multiple-source random information delays that inevitably exist for the CAV system, which largely lead to poor CAV control performance. In this study, we propose a novel CAV robust string-stable car-following control approach based on the linear controllers, so that the CAV system has guaranteed stability and robustness against multiple-source information delays. First, the generic delay-robust car-following controllers of CAVs are developed based on the delay compensating policy and Smith predictor considering multiple-source information delays. Moreover, the stability analysis of the proposed CAV control system is conducted, in which the sufficient conditions of string stability in the frequency domain are derived based on the Laplace transform. The results from numerical experiments demonstrate the mathematical proofs of stability analysis and the effectiveness of the proposed CAV control system on stability performance compared with the baseline control system.

Keywords: connected and automated vehicles; multiple information delays; robustness; stability; verifications

# REAL-TIME ESTIMATION OF RESIDUAL VEHICLES AT A SIGNALIZED INTERSECTION VIA PARTIAL CONNECTED VEHICLES

A. Shaocheng JIA [a], B. S.C. WONG [a*], C. Wai WONG [b*] and D. Xin PEI [c]
[a] *Department of Civil Engineering, The University of Hong Kong, Hong Kong SAR, China*
[b] *Department of Civil and Natural Resource Engineering, University of Canterbury, New Zealand*
[c] *Department of Automation, Tsinghua University, Beijing, China*
**Email: hhecwsc@hku.hk; wai.wong@canterbury.ac.nz (Corresponding author)*

Emerging connected vehicle (CV) technologies present unprecedented opportunities to perform cycle-by-cycle adaptive signal control without requiring on-road detectors. Residual vehicles in all controlling lanes, which are the undischarged vehicles at the end of a common cycle and serve as essential initial conditions for minimizing traffic delays, must be determined to optimize signal timings for the next cycle. However, the prolonged transition period implies a mix of CVs and non-connected vehicles (NCs) within transportation networks, resulting in incomplete traffic information. This paper addresses this problem by developing a generic and fully analytical CV-based residual vehicle (CVRV) model to estimate the number of residual vehicles on a cycle-by-cycle basis, relying solely on partial CV trajectory data. The CVRV model is applicable to scenarios with any signal plans, CV penetration rates, and traffic demands. The average arrival rate and CV penetration rate serve as essential inputs for the CVRV model and are determined via a maximum likelihood estimation. Two sub-models, namely the CVRV-I and CVRV-II, are derived to account for different residual vehicle patterns in cycles ending with effective red and green lights. Each sub-model handles various residual vehicle patterns, including distinct residual vehicle components such as stopped residual CVs and NCs, and moving residual CVs and NCs. The effectiveness of these sub-models is demonstrated through comprehensive numerical experiments in scenarios with various volume-to-capacity ratios, CV penetration rates, and signal timing combinations. These scenarios are tested on the VISSIM platform.

Keywords: Connected vehicle; penetration rate; residual vehicle estimation; signalized intersection

# COOPERATIVE LANE-CHANGING OPTIMIZATION OF CONNECTED AND AUTONOMOUS VEHICLES IN FREEWAY MERGING AREA

A. Xuling LIU [a*] and B. Xiaoning Zhang [a*]

[a] *School of Economics & Management, Tongji University, Shanghai, 201804, China*

**Email: shirley_20001002@163.com; cexzhang@tongji.edu.cn (Corresponding author)*

In the freeway merging area, the behavior of vehicles changing lanes for confluence is highly free. However, the lack of cooperative lane-change information between vehicles makes the confluence of mainline vehicles and ramp vehicles easy to cause congestion. The technology of Connected and Autonomous Vehicles (CAV) allows information interaction and cooperation between vehicles, which can effectively solve this problem and improve the efficiency of vehicle merging. Based on this, this study proposes a merging optimization framework and lane change control strategy in CAV environment. The framework divides the merging area into cooperative lane-change area and trajectory optimization area, allowing real-time control of continuous traffic flow. This study uses VISSIM to build a research scenario, and uses VISSIM Com and Python to control the behavior of CAV. In the cooperative lane-changing area, the optimal number of lane-changing vehicles is determined by considering the balance of traffic distribution in the inner and outer lanes downstream of the confluence area. Then, based on the analysis of CAV cooperative lane-changing mode, the order and combination of cooperative lane-changing vehicles are determined. In the trajectory optimization zone, the speed and acceleration of each vehicle are optimized by the trajectory optimization model, so that CAV can pass the confluence point safely and efficiently along the optimized trajectory. The simulation platform is used to evaluate the average speed, average delay time and throughput of these strategies, so as to verify the effectiveness of the proposed strategies.

Keywords: Freeway Merging Area; Connected and Autonomous Vehicles (CAV); lane-changing optimization; simulation

# COMMUNICATING WITH ONLY TWO VEHICLES IMMEDIATELY AHEAD BOOSTS TRAFFIC CAPACITY SIXFOLD IN CONNECTED AUTONOMOUS VEHICLE (CAV) PLATOONS

A. Shi-teng ZHENG [a], B. Rui JIANG [a*] and C. Xiqun (michael) CHEN [b]
[a] *School of Systems Science, Beijing Jiaotong University, Beijing 100044, China*
[b] *Institute of Intelligent Transportation Systems, College of Civil Engineering and Architecture, Zhejiang University, Hangzhou 310058, China*
[*] *Email: jiangrui@bjtu.edu.cn (Corresponding author)*

Due to the continuous inflow of new vehicles far outweighing the outflow of scrapped vehicles, urban areas are experiencing a severe traffic congestion resulting from the surge number of vehicles. Addressing urban congestion through enhanced traffic capacity has emerged as a critical objective for connected autonomous driving technologies. An irredundant communication connectivity topology is essential for ensuring the high efficiency and stability of the traffic system, which has not been fully validated, due to the scarcity of real-world tests. Motivated by the fact, this paper deploys a connected autonomous vehicle (CAV) platoon without relying on the information of a platoon leader to preserve the possibility of extending the platoon in future practical applications. A real-world CAV platooning experiments is conducted that following CAVs communicate with two vehicles immediately ahead if there be. The simulation-to-reality gap is captured and bridged to allow us to perform tests in realistic simulation environment. The performance of the large-scale CAV deployment is evaluated under typical corridor and on-ramp merging scenarios. Our findings highlight that communicating with vehicles immediately ahead enables a long, tight, and stable platoon. It provides valuable insights into the sixfold traffic capacity improvement with communicating only two vehicles ahead in theorical perspective and the practicality of such a communication connectivity topology from real-world experimental validation.

Keywords: Connected Autonomous Vehicle, Field experiment, Communication connectivity topology, Sim-to-Real, Vehicle platooning

SESSION E2: Traffic Equilibrium and Network Optimization

# A TWO-PHASE APPROACH FOR MULTIMODAL TRAFFIC EQUILIBRIUM ASSIGNMENT BASED ON NETWORK GENERALIZED EXTREME VALUE MODEL

A. Muqing DU [a*], B. Dongyue CUN [a], C. Guoyuan LI [b] and D. Anthony CHEN [b]

[a] *College of Civil and Transportation Engineering, Hohai University, Nanjing, China*

[b] *Department of Civil and Environment Engineering,*
*The Hong Kong Polytechnic University, Hong Kong, China*

[*] *Email: dumqhhu@hhu.edu.cn (Corresponding author)*

The multimodal traffic equilibrium assignment problem (M-TEAP) is a very classical problem that was depicted by the combined modal split and traffic assignment (CMSTA) model. Recent studies were devoted to explicitly considering the combined travel modes in the M-TEAP, as a significant portion of the daily travels in the modern urban metropolis are realized using multiple modes. To address the challenges of enumerating combined modes in existing multimodal traffic equilibrium models, this study proposes a novel two-phase approach for characterizing the combined travel modes in a multimodal transportation network. It converts the multimodal transportation network structure into a two-layered network, in which the upper-level network captures the mode combinations between the origin/transfer/destination nodes. Based on the two-layered network, we formulate a combined mode choice and route choice model based on the network generalized extreme value (NGEV) model, which effectively captures both underlying mode similarity and path correlation without explicitly listing all possible combinations of modes and paths. The existence and uniqueness of the proposed model are demonstrated by formulating the M-TEAP as a fixed-point problem. Experimental results show that the two-phase method outperforms the method that conducts the equilibrium combined path flows at a time, as it avoids unreasonable mode transfer and provides a more practical traffic assignment flow pattern.

Keywords: Multimodal transportation network, Combined travel mode, Equilibrium assignment, Network generalized extreme value, Two-phase approach

# URBAN ECONOMIC ANALYSIS INCORPORATING A QUASI-DYNAMIC TRAFFIC ASSIGNMENT MODEL

A. Jiang Qian YING [a*]

[a] *Department of Regional Policies, Faculty of Regional Studies Gifu University, Gifu, Japan*

**Email: ying.jian.qian.i6@f.gifu-u.ac.jpk (Corresponding author)*

Transportation costs, particularly commuting costs, are pivotal aspects of urban economic analysis. The configuration of urban space hinges significantly on the trade-off between commuting costs and residential location costs and environmental quality. The commuting behavior is also a cause of the temporal variation in traffic flows, characterized by rush hour peaks. The consideration of the traffic flow dynamics is important in urban economic analysis.

In this paper, we incorporate a quasi-dynamic traffic assignment model, which captures the dynamic features of traffic flows while maintaining a simple mathematical structure, into an urban economic model for the optimization of regulations and fiscal policies for residential land use and traffic management. Numerical results suggest that a conventional urban model with static traffic assignment may overestimate the cost of long-distance commuting, predicting a more compact urban space than reality. Such biases could be corrected by the incorporation of a dynamic traffic model.

Keywords: dynamic traffic assignment, urbane economics, land use regulation, fiscal policies, optimization

# ACTIVE NETWORK OPTIMISATION: ADDRESSING CONFLICTS BETWEEN ETHICS AND FAIRNESS IN TRANSPORT NETWORKS

A. M. MEMARPOUR [a*], B. A. NAJMI [a], C. T.S. WALLER [b] and D. T.H. RASHIDI [a]

*[a] Research Centre for Integrated Transport Innovation (rCITI), School of Civil and Environmental Engineering, University of New South Wales, Kensington, UNSW Sydney, NSW 2052, Australia*

*[b] Chair of Transport Modelling and Simulation, TU Dresden, 01069 Dresden, Germany*

**Email: m.memarpour@unsw.edu.au (Corresponding author)*

During recent decades, a paradigm shift toward sustainable environment has led transport planners to develop micro-mobility and active mode infrastructures to improve the sustainability of the transport networks. One critical issue in designing active networks is its safety. It is not only regarded as an efficiency measure from a cost-benefit analysis perspective, but, due to dealing with the death and life of people, also acknowledged as the ethics of a design in terms of both risk quantity and its fairness, e.g., how the safety risks are distributed among users. In this study, we aim to optimise the design of a bi-modal active network in terms of fairness of safety risk considering the safety index constraint as its ethical measure as well as budget constraint in development of the network. To this end, we develop a bilevel optimisation model addressing all the mentioned constraints. Then, based on full enumeration of available design policies and simulation of different network demand configurations on a test network, we determine the characteristics of optimal solutions. The results suggested that, regardless of the network structure, there is an inherent conflict between safety fairness and its absolute value considering the budget limitation. In the last phase, the simulation results are used as heuristics in a Genetic Algorithm to solve the bi-level problem in a larger-scale network.

Keywords: Active network design, safety improvement, ethics and fairness, bi-level optimisation

# MODELING THE EFFECT OF CAPACITY CONSTRAINTS AND QUEUING TOLL POLICIES IN A BI-MODAL TRANSPORTATION NETWORK INCLUDING SOLO DRIVING AND CARPOOLING BEHAVIOR

A. Yanqin CHEN [a], B. Changxin LIAO [a], C. Jia YAO [a*], D. David Z. W. WANG [b] and E. Anthony CHEN [c]

*[a] School of Economics and Management,*
*Dalian University of Technology, Dalian, Liaoning 116024, China*
*[b] School of Civil and Environmental Engineering,*
*Nanyang Technological University, 50 Nanyang Avenue 639798, Singapore*
*[c] Department of Civil and Environmental Engineering,*
*The Hong Kong Polytechnic University, Hung Hom, Hong Kong*
**Email: yaojia@dlut.edu.cn (Corresponding author)*

In urban transportation systems, promoting carpooling can usually effectively increase network capacity and alleviate traffic congestion, especially in some cities with underdeveloped public transportation systems. This paper integrates the features of carpooling to propose two queueing toll policies aimed at eliminating physical queuing in a mixed transportation network involving solo driving and carpooling, with explicit consideration of capacity constraints. First, we develop a bi-modal mixed traffic equilibrium model with capacity constraints under three cases: (1) physical queuing case, wherein no queuing tolls are implemented for all travelers (case 1); (2) differential queuing toll policy case, in which queuing toll policy is implemented exclusively for solo drivers aimed at eliminating physical queuing, and considering the scenario that is only carpooling on saturated links with physical queuing (case 2); (3) uniform queuing toll policy case, wherein queuing toll policy is implemented for both solo drivers and carpoolers (case 3). Second, we design an improved bi-loop algorithm to solve this model. Third, we conduct the numerical analysis to demonstrate (a) the impacts of adding a new link on the performance of transportation network under three cases, such as the network capacity, travel choice behavior and average travel costs; (b) the occurrence of traffic paradoxes, e.g., capacity paradox, capacity-toll paradox, Braess paradox and Braess-toll paradox; and (c) the impacts of three cases on the performance of a practical network, the Sioux Falls network. Some general insights are concluded based on the numerical analysis.

Keywords: Queuing toll; Capacity constraints; Solo driving; Carpooling; Traffic paradoxes

# LIPSCHITZ CONTINUITY IN INTERACTION FOR STABLE EQUILIBRIUM OF MULTI-AGENT JOINT CHOICE MODELS

A. D. OGAWA [a] and B. E. HATO [a*]
[a] *Department of Civil Engineering, The University of Tokyo, Japan*
[*] *Email: hato@bin.t.u-tokyo.ac.jp (Corresponding author)*

With the diversification of transportation modes, the importance of evaluating the interactions between different modes of transportation in urban street spaces is increasing. However, the evaluation of interactions between transportation modes faces the issue of endogeneity, where the behavior of other transportation modes affecting one's behavior depends on the actions taken by the others. To address this, there is a method that leverages adversarial inverse reinforcement learning, that is interpretable as a Markov game. That method estimates a policy function that depends on the behavior of others by using a behavior function during model training. However, the equilibrium state estimated by this method is not necessarily stable. In this study, using a twin experiment, the stability of the equilibrium states are analyzed, when a regularization method is applied to the objective function of model learning to estimate endogenous interactions between transportation modes as stable equilibrium states.

Keywords: route choice model, interaction estimation, stability analysis, multi-transportation

SESSION E3: Urban Air Mobility Infrastructure Planning

# INTEGRATED PLANNING OF VERTIPORTS AND VERTIPADS INFRASTRUCTURE FOR URBAN AIR MOBILITY

A. Ning LYU [a] and B. Tao FENG [a*]

[a] *Graduate School of Advanced Science and Engineering, Hiroshima University, Higashi-Hiroshima, Japan*

**Email: taofeng@hiroshima-u.ac.jp (Corresponding author)*

To maximize the benefits of recently promoted UAM in reducing traffic congestion, it is essential to plan the relevant infrastructure and efficiently connect UAM with other mobility options (e.g., metro, taxi). This highlights the key role of synchronized multimodal network services in planning UAM infrastructure. However, little is known regarding UAM infrastructure planning (i.e., vertiport, vertipad) from the perspective of multimodal transport networks. This study proposes a model to optimize vertiport locations and the number of vertipads at each vertiport, considering the constraints related to construction and travel costs of multimodality. The goal is to determine the optimal locations and numbers of vertiports and vertipads under the constraints of construction costs, UAM travel demand, and maximum waiting time. A Multinomial Logit model and Multi-Server Queueing Theory are integrated to respectively predict the UAM demand and the waiting time at each vertiport. To solve the optimization model, Lagrangian relaxation with a Benders Decomposition algorithm is developed considering the non-linear travel demand. Results of a case study show the proposed algorithm provides a robust and efficient solution. Additionally, results of sensitivity analyses reveal that variables such as coverage radius and demand coverage rate of UAM services critically influences the number of vertiports and vertipads required. The proposed modeling framework offers a useful tool for policymakers to guide the sustainable development of UAM infrastructure in multimodal networks.

Keywords: Urban Air Mobility (UAM), Vertiport Optimization, Logit model, Queuing theory, Benders Decomposition

# URBAN SKIES REIMAGINED: FACTORS DRIVING ADVANCED AERIAL MOBILITY ACCEPTANCE IN CHINA'S GREATER BAY AREA

A. Eric Th CHAN [a*], B. Tingting Elle LI [a] and C. Tim SCHWANEN [b]
[a] *School of Graduate Studies, Lingnan University, Hong Kong SAR, China*
[b] *Transport Studies Unit, School of Geography and the Environment, University of Oxford, UK*
**Email: ericchan3@ln.edu.hk (Corresponding author)*

In the era of rapid urbanisation and technological innovation, Advanced Aerial Mobility (AAM) emerges as a potential solution to various urban transportation challenges. This study examines the societal acceptance of AAM – a sustainable transport mode utilising electric vertical take-off and landing (eVTOL) aircraft – within China's Greater Bay Area (GBA), a region grappling with air pollution, traffic congestion, and cross-border mobility issues. By synthesising the Theory of Planned Behaviour (TPB) and Technology Acceptance Model (TAM), we propose an extended model that incorporates trust as a crucial construct. Our model, empirically tested with a survey of 988 GBA residents, unveils the intricate factors shaping the intention to embrace this innovative mode of transport. Structural Equation Modelling confirms the model's validity, explaining 61% of the variance in AAM usage intention. In the proposed model, trust is identified as the most significant factor in explaining the acceptance of AAM. Our multigroup analyses further reveal nuanced insights: perceived usefulness and subjective norms significantly influence young adults' intentions, while perceived behavioural control plays a pivotal role in shaping men's inclination towards AAM adoption. These findings not only contribute to the theoretical understanding of technology acceptance but also offer valuable practical implications for informing the design, implementation, and regulation of AAM development in the GBA and beyond. By illuminating the factors driving AAM acceptance, this study paves the way for reimagining urban mobility in the skies of tomorrow.

Keywords: Advanced aerial mobility; urban air mobility; technology acceptance; trust; theory of planned behaviour

As at December 7, 2024

# FLYING PATH PLANNING WITH GROUND RISK AND NOISE MITIGATION FOR URBAN AIR MOBILITY

A. Yini CHEN [a*], B. Rao FU [b] and C. Shuai JIA [a]
[a] *Thrust of Intelligent Transportation,*
*The Hong Kong University of Science and Technology (Guangzhou), Guangzhou, China*
[b] *Department of Industrial and Manufacturing Systems Engineering,*
*The University of Hong Kong, Hong Kong, China*
**Email: ychen361@connect.hkust-gz.edu.cn (Corresponding author)*

The rapid development of electric Vertical Take-off and Landing (eVTOL) technology has positioned the urban air mobility (UAM) system as a promising solution for alleviating urban traffic congestion. However, the operation of eVTOLs in urban environments poses critical public concerns, particularly the noise pollution and the possibility of unexpected crashes leading to ground fatalities. Therefore, the design of efficient, safe and low-noise eVTOL flying paths is the key to successful UAM operations. Existing research mainly focus on minimizing flight distance or energy consumption, often overlooking the important aspects of risk and noise assessment. This paper studies a flying path planning problem for UAM with the considerations of noise and risk avoidance. We propose a comprehensive ground risk assessment model and a noise pollution assessment model tailored for low-altitude eVTOLs operations within typical metropolitan areas. On top of this, a mixed integer programming model is developed to optimize the eVTOL flying paths with respect to risk and noise performance metrics. To solve the problem efficiently, we develop an improved Bidirectional-RiskA*-Dubins (BiRAD) algorithm, which conducts bidirectional path searches on pre-generated risk and noise maps to produce optimal planned trajectories of eVTOLs. We test the proposed solution method in the case of the Nansha District of Guangzhou City and demonstrate the superior performance in both computation efficiency and solution quality compared against well-established benchmark methods.

Keywords: Urban air mobility; flying path design; ground risk avoidance; noise pollution mitigation; mixed integer programming.

# A HYBRID FRAMEWORK OF TRAFFIC SIMULATION AND MANAGEMENTFOR LARGE-SCALE URBAN AIR MOBILITY

A. Canqiang WENG [a], B. Can CHEN [b], C. Tianlu PAN [c] and D. Renxin ZHONG [a*]

[a] *School of Intelligent Systems Engineering,*
*Sun Yat-Sen University, Shenzhen, China*

[b] *Department of Civil and Environmental Engineering,*
*The Hong Kong Polytechnic University, HongKong, China*

[c] *Department of Network Intelligence, Peng Cheng Laboratory, Shenzhen, China.*

**Email: zhrenxin@mail.sysu.edu.cn (Corresponding author)*

Urban air mobility (UAM) is an emerging mode that uses low-altitude airspace to provide point-to-point air travel services. Recent advances in electric vertical take-off and landing vehicles are increasing attention on UAM for its potential to alleviate roadway traffic congestion. Given the spatial heterogeneity of land use in most cities, large-scale UAM will likely be deployed between specific urban areas, for example, from the suburbs to city centers. However, large-scale UAM travel between a few origin-destination pairs increases the risk of aircraft collisions and air traffic congestion, especially at airline intersections. To address this, this work proposes a hybrid framework of traffic simulation and management for large-scale UAM. The framework achieves an elegant trade-off between air traffic safety and efficiency by combining route guidance and collision avoidance for UAM aircraft. With a centralized strategy, route guidance provides time-efficient paths (composed of waypoints) for aircraft, aiming to minimize total travel time. With a distributed strategy, collision avoidance generates trajectories between given waypoints, ensuring aircraft safety separation. To the best of our knowledge, this work is one of the first to introduce both dynamic route guidance and collision avoidance for UAM. The results highlight that the framework can effectively prevent air traffic congestion and provide flexible UAM operations, e.g., dynamic airspace access management. The proposed framework has demonstrated great potential for large-scale UAM simulation and management.

Keywords: Urban air mobility, Multi-agent systems, Collision avoidance, Air traffic congestion, Route guidance

# COMPARISON OF NEW MOBILITY SERVICES USING RP-SP MODE CHOICE MODELS CONSIDERING LATENT VARIABLES AND HETEROGENEITY

A. H. HASADA [a, b*], B. A. MIZUNO [b], C. Y. GAO [c], D. S. KITAMURA [b] and E. R. KANAMORI [d]
[a] *Institute of Industrial Science, The University of Tokyo, Japan*
[b] *The Institute of Behavioral Sciences, Japan*
[c] *PayPay Corporation, Japan*
[d] *Institutes of Innovation for Future Society, Nagoya University, Japan*
[*] *Email: hasada@iis.u-tokyo.ac.jp (Corresponding author)*

The technologies for new mobility services using artificial intelligence, such as DRT (Demand Responsive Transport) services and autonomous vehicle (AV) services have developed rapidly. Although these services are expected to complement sustainable transport systems by replacing declining conventional feeder bus, they have not yet implemented due to unclear preference on them. In this study, we analyze the underlying structure of user intentions using mode choice models based on revealed preference data and stated preference data for an DRT service and an AV service. Our proposed models incorporate various indicators of attitudes towards the new services and personal mobility into mode choices with latent variables, taking into account heterogeneity in the value of time. In other words, the proposed models integrate ICLV (Integrated Choice and Latent Variable) model, RP-SP (Revealed Preferences and Stated Preferences) model, and MMNL (Mixed Multi-Nomial Logit) model. This allows detailed comparisons of the individual attributes and sensitivities of users to understand the characteristics of each new service. Our study contributes to appropriate fare structures and targeting when it comes to providing new mobility services in a real field.

Keywords: self-driving, demand responsive transport services, mode choice, ICLV model, RP-SP model

## SESSION E4: Mixed Autonomy Traffic Systems

# DAY-TO-DAY TRAFFIC CONTROL FOR NETWORKS MIXED WITH REGULAR HUMAN-PILOTED AND CONNECTED AUTONOMOUS VEHICLES

A. Qingnan LIANG [a], B. Xin-an LI [b], C. Zhibin CHEN [a], D. Tianlu PAN [c] and E. Renxin ZHONG [b,*]

[a] *Division of Engineering and Computer Science, NYU Shanghai, Shanghai, China.*

[b] *Guangdong Key Laboratory of Intelligent Transportation Systems, School of Intelligent Systems Engineering, Sun Yat-Sen University, Guangzhou, China.*

[c] *Department of Networked Intelligence, Peng Cheng Laboratory, Shenzhen, China.*

**Email: zhrenxin@mail.sysu.edu.cn (Corresponding author)*

The emerging connected autonomous vehicle (CAV) technology offers a significant opportunity to address the congestion problem caused by the selfish routing behavior of human drivers. If system managers can control the routing of all vehicles on the network, they could easily reverse this effect. However, during the transition period, CAVs will share roads with human-piloted vehicles (HVs). In the era of mixed autonomy, a more realistic scenario is to route the CAVs to lead the traffic state toward the desired equilibrium. We can consider a repeated routing game in which the system manager can control the routes of CAVs to minimize the system travel time, i.e., CAVs follow the system optimal (SO) routing principle. In this manner, we can influence the travel time traversing each link, which indirectly influences HV users' route choices. As a consequence, HV users may adjust their routes dynamically through day-to-day (DTD) learning to minimize individual travel cost. On the other hand, the SO routing strategy may induce higher travel time for CAVs than HVs within the same origin-destination (OD) pair. To address such inherent unfairness, road pricing is used to influence route choices of HVs to achieve specific supply regulation targets, e.g., traffic restraint. We present qualitative analysis on the effect of road pricing regarding unfairness. To the best of our knowledge, this paper is one of the first to design dynamic pricing schemes for a mixed autonomy system under DTD learning dynamics. We carry out numerical experiments to demonstrate the effectiveness of the control schemes. The cooperative CAVs could reduce the total travel time when the market penetration rate of CAVs reaches the lower minimum control ratio that the network could escape the user equilibrium (UE) condition. When the market penetration rate of CAVs reaches the upper minimum control ratio, the network would achieve SO condition even though there are non-cooperative HVs. On the other hand, the pricing scheme can reduce the unfairness index and total travel time of the network when the market penetration rate of CAVs is low.

Keywords: Day-to-day dynamics; Mixed equilibrium; Road pricing; Unfairness; Minimum control ratio

# A MODULAR MULTI-PURPOSE VEHICLE ROUTING PROBLEM WITH COUPLING AND DECOUPLING: USING MODULAR AUTONOMOUS VEHICLES FOR COLLABORATIVE PASSENGER AND FREIGHT TRANSPORT

A. Yingying SUN [a] and B. W.Y. SZETO [a*]
[a] *Department of Civil Engineering, The University of Hong Kong, China*
**Email: ceszeto@hku.hk (Corresponding author)*

Modular Autonomous Vehicles (MAVs) are driverless vehicle pods that can autonomously connect and disconnect with each other to form platoons, adapting their vehicle capacities on urban roads. With this new technology, flexible coupling and decoupling operations of MAVs in collaborative passenger and freight transportation have become possible but have not been investigated yet. To address the research gap, this study proposes two mechanisms which enable MAVs of the same or different types to form platoons flexibly, either by waiting at the customer locations or making detours without affecting customer services. To optimize the routing and platoon configurations of MAVs within the integrated transportation framework, a mixed integer programming (MIP) model based on a time-space network is established, and the waiting behaviors of MAVs in the system are discussed in detail. The model aims to strike a balance between reducing the total energyrelated distance through flexible platoon formation and minimizing both total trip durations and the total number of unserved requests. To showcase the benefits of the proposed system with the platooning mechanisms, two benchmark models are established and compared against the primary model, with all models solved using GUROBI. The numerical experiments with a test example indicate that the proposed system effectively reduces the total energy-related distance while maintaining a high level of customer service and compromising only a modest increase in total trip durations.

Keywords: modular autonomous vehicles; platooning mechanism; collaborative passenger and freight transport; mixed integer programming model; time-space network

# MACROSCOPIC MODELING AND OPTIMIZATION OF TWO-REGION MIXED AUTONOMY NETWORK WITH PARK-AND-RIDE

A. Yifan LI [a], B. Ziyuan GU [a*], C. Nan ZHENG [b], D. Wei MA [c] and E. Zhiyuan LIU [a]
[a] *School of Transportation, Southeast University, Nanjing, China*
[b] *Institute of Transport Studies, Department of Civil Engineering, Monash University, Victoria, Australia*
[c] *Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hong Kong, China*
[*]*Email: ziyuangu@seu.edu.cn (Corresponding author)*

The transition period of mixed autonomy networks, where connected and automated vehicles (CAVs) coexist with human-driven vehicles (HDVs), is anticipated to reshape urban traffic dynamics. This abstract presents a dynamic macroscopic model of two-region mixed autonomy networks, integrating park-and-ride (P&R), with a focus on morning peak-hour commuting scenarios. The model offers a quantitative tool to evaluate and optimize urban P&R policies. Key contributions include a novel two-region mixed autonomy network model with adaptive macroscopic fundamental diagram (MFD) and an extended multi-pool representation accounting for P&R behavior, cruising-for-parking phenomenon, and self-parking CAVs. The adaptive MFD incorporates varying CAV penetration rates using the Markov chain method. Cruising-for-parking distance estimation employs a piecewise function to mitigate underestimation, where the first piece is derived using the idea of non-replacement sampling, while the second piece is an exponential function. The utility function, integrating time and cost, underpins parking choice modeling for both HDVs and CAVs. The multinomial logit model is used to describe driver's random choice behavior, while a Monte Carlo method is employed to characterize the deterministic decisions of CAV. The system dynamics model, utilizing mass conservation equations, captures the flow of vehicle families and their interactions. An experiment conducted on a two-region mixed autonomy network in the Melbourne metropolitan area demonstrates the efficacy of the model. Under optimal pricing, congestion in the city center is alleviated, leading to reduced accumulation and improved trip completion rates. The model's versatility facilitates Informed decision-making on urban parking policies, thereby enhancing mobility management in mixed autonomy networks.

Keywords: Park-and-ride; Mixed autonomy network; Parking dynamics; Network macroscopic fundamental diagram; Connected and automated vehicle

# MODELLING THE SOCIAL INTERACTIONS AT MIXED-FLOW INTERSECTION WITH MULTI-AGENT IMITATION LEARNING

A. Shihan WANG [a], B. Ying NI [a], C. Jian SUN [a] and D. Jie SUN [a*]

[a] *Department of Traffic Engineering & Key Laboratory of Road and Traffic Engineering of the Ministry of Education, Tongji University, Shanghai, China*

**Email: jie_sun@tongji.edu.cn (Corresponding author)*

Virtual simulation testing is a core approach for evaluating the social interaction capabilities of autonomous vehicles during their development. However, existing traffic simulation models mainly focus on generating accurate vehicle trajectories and have not explicitly modelled the social interactions, which capture the social intent decisions and guide decision-making and movements in complex interactions. This study aims to address this gap by developing a data-driven simulation model for the social interaction behaviours at mixed-flow intersection based on the multi-agent imitation learning (MAIL) approach, which is referred to as social-MAIL model. Specifically, to quantify the sociality of decision, we introduce the social value orientation into the reward function to capture the cooperation or competition intents and guide the generation of social driving behaviours. Further, to fully depict the complex interaction environment, we develop a heterogeneous policy network with temporal-spatial attention mechanisms to describe the impact of multiple interactive objects and historical states on driving behaviours. Through training and validating based on the SinD dataset, we demonstrate that the proposed social-MAIL model can accurately capture the complex and time-varying social interactions and reproduce the most realistic vehicle trajectories and macroscopic traffic flow characteristics compared to a set of baseline models. This underscores the significant potential of the social-MAIL model for AV testing.

Keywords: Mixed-flow Intersection Simulation; Social Interactions Modelling; Social Value Orientation; Multi-agent Imitation Learning; Temporal-spatial Attention

# INFRASTRUCTURE-ENABLED AUTOMATED NETWORK DESIGN FOR MIXED TRAFFIC

A. Qingyun TIAN [a], B. Yun Hui LIN [b] and C. David Z.W. WANG [a*]

[a] *School of Civil and Environmental Engineering,*
*Nanyang Technological University, Singapore*

[b] *Institute of High Performance Computing (IHPC), Agency for Science, Technology and Research (A*STAR),*
*1 Fusionopolis Way, #16-16 Connexis, Singapore 138632, Republic of Singapore*

[*] *Email: wangzhiwei@ntu.edu.sg (Corresponding author)*

Infrastructure-enabled autonomous driving system has been proposed as a promising solution to mitigate the high costs associated with AVs. By equipping ordinary roads with roadside sensing, computing, and communication devices, these roads can be transformed into ‘‘automated roads". This upgrade enables autonomous driving services for vehicles with minimal on-board equipment requirements. In this study, we explore the concept of redesigning road links within urban transportation networks into infrastructure-enabled automated (IEA) links, allowing infrastructure enables autonomous vehicles (IEAVs) to autonomously navigate these specially designed roads. To further incentivize the adoption of IEAVs, we investigate the provision of the purchase subsidy simultaneously. To this end, we propose a mathematical model to assist planners in deciding the deployment of IEA roads and determining IEAV's purchase subsidies within a limited budget. To depict travelers' behaviors under mixed traffic conditions, we employ a combined multinomial logit model for vehicle mode choice and user equilibrium for route choice. The model properties and the resultant variational inequality (VI) reformulation are investigated as well. Subsequently, we introduce a Bayesian optimization algorithm to search for optimal solutions, in which a modified double projection method is proposed to solve the joint vehicle mode choice and route choice in the function evaluation process. Numerical studies are conducted to test the proposed model, and sensitivity analysis is conducted to test the impacts of various parameters. The results show that the proposed model works well in reducing the total travel cost and improving the adoption of IEAVs.

Keywords: Mixed traffic, Infrastructure-enabled automated driving, Network design, Subsidy design

SESSION E5: Route Choice and Traffic Modeling

# JOINT ESTIMATION OF LATENT OD MATRIX AND 3D ROUTE CHOICE MODEL ACROSS RAILWAY STATION BOUNDARIES BASED ON MANIFOLD LEARNING

A. Takahiro MATSUNAGA [a] and B. Eiji HATO [a*]
[a] *Department of Civil Engineering, The University of Tokyo, Japan*
[*] *Email: hato@bin.t.u-tokyo.ac.jp (Corresponding author)*

Transportation hubs such as railway stations are pivotal centers of pedestrian flow in urban areas. For the optimal design of urban environments, it is essential to consider pedestrian movement within stations and the surrounding urban areas as a unified system. However, due to the observational challenges, integrated analyses that encompass both inside and outside station boundaries have rarely been implemented. This study aims to develop a framework for integrative describing behavioral principles both inside and outside stations by leveraging diverse observational data, including Bluetooth Low Energy (BLE) signals and camera data. We propose the manifold learning-based method for simultaneous estimation of OD distribution across station boundaries and route choice model parameters, treating OD matrices as latent variables. Using this framework, we conducted a case study at Shibuya Station, which is one of Tokyo's largest and most complex stations, characterized by high congestion levels. With BLE, camera data, and survey results, we estimated OD distributions and route choice models across different time periods, examining temporal changes in OD patterns. The findings reveal dynamic shifts in OD distributions within the Shibuya area, which are corroborated by the use of mobile spatial data provided by a telephone carrier, demonstrating the efficacy of our approach in analyzing real-world pedestrian flow.

Keywords: manifold learning, OD-matrix estimation, BLE (Bluetooth Low Energy), railway stations

# DYNAMICS OF IN-STATION TIME WITHIN METRO SYSTEMS: MEASUREMENT AND DETERMINING FACTORS

A. Hui WANG [a*] and B. Becky P.Y. LOO [a]

[a] *Department of Geography, The University of Hong Kong, China*

**Email: huiwanghk@connect.hku.hk (Corresponding author)*

Worldwide, people living in mega cities are increasingly dependent on metro systems. Their travel experience, however, has not been closely examined. In particular, travel time estimates often do not consider in-station time, which can be significant, especially at large interchange stations with multiple exits and platforms. This study represents a novel attempt to measure in-station time dynamics systematically, considering a wide range of factors such as station design and layout, passenger volume and interaction, and operational schemes. An agent-based modelling approach is used to simulate movement dynamics within metro stations. Then, a robust quantile regression model is built to capture the variability of in-station time and analyze the underlying factors. Four operation scenarios are simulated for the weekday peak, the weekday non-peak, the weekend peak, and a festival holiday peak at two metro stations in Hong Kong. The findings reveal that the in-station time distribution is the longest during the festival holiday peak, followed by weekday non-peak, weekend peak and then weekday peak. The in-station time varies from 2.5 to 27.5 minutes, which represents up to 10 times of the in-vehicle time for metro trips within the urban core. Based on the findings, the study recommends both long-term measures, such as increasing the number and density of entrances/exits, and short-term measures, such as providing more escalators at entrances/exits, augmenting the number of inbound ticket gates, improving the experience of transfer passengers, streaming flows to escalators at platforms, and optimizing headways.

Keywords: In-Station Time; Agent-based Simulations; Station Design; Station Operation; Quantile Regression

# A FAST ALGORITHM FOR COMPUTING ROUTE CHOICE PROBABILITIES IN LARGE-SCALE DYNAMIC ROAD NETWORKS

A. Kouki MATSUMOTO [a*], B. Masaaki ISHIHARA [a*] and C. Takamasa IRYO [a*]
[a] *Graduate School of Information Sciences, Tohoku University, Japan*
[*] *Email: matsumoto.koki.q6@dc.tohoku.ac.jp; ishihara.masaaki.r7@dc.tohoku.ac.jp; iryo@tohoku.ac.jp (Corresponding authors)*

Traffic flow simulators are helpful for accurately predicting the impact of policies on road network construction and management. As traffic simulators calculate a traffic flow that changes in a day, the route choice model has to accommodate link travel times that dynamically change over time. It should also incorporate errors in drivers' perception, which invokes the necessity of calculating route choice probabilities. This study extends the perturbed utility route choice model (PURC; Fosgerau et al. 2022) to develop a fast algorithm calculating route choice probabilities in a large-scale dynamic network. The proposed method employs a perturbation term based on the sum of the link choice probabilities for all time intervals to disperse routes using the same link at different times appropriately. The proposed method was tested on a large-scale road network in the Kansai area in Japan. The proposed method calculated route and link choice probabilities with comparable accuracy and fewer iterations than the Monte Carlo method. The number of routes enumerated by the d-PURC was considerably smaller than by the Monte Carlo method, and it tended to distribute the probabilities over routes with lower similarity.

Keywords: route choice probabilities, stochastic choice model, large-scale dynamic road networks, choice set generation, traffic flow simulator

# PRIORITY-BASED CHARGING STRATEGY FOR AUTONOMOUS MOBILE ROBOTIC CHARGERS FOR ELECTRIC VEHICLES

A. Jeong. SEOMUN [a], B. Seunghyeon. LEE [a] and C. Jihye. BYUN [a*]
[a] *Department of Transportation Engineering,*
*University of Seoul, Seoul, Republic of Korea*
[*] *Email: jhbyun@uos.ac.kr (Corresponding author)*

This study proposes priority-based charging strategy for autonomous mobile robotic chargers serving electric vehicle users. Our objective is to ensure the most possible number of accepted charging requests within dynamic charging environments and under time constraints. To achieve this objective, we determine the optimal visiting order for charging using a Dynamic Vehicle Routing Problem with Stochastic Requests. There are three primary contributions in the proposed charging strategy. Using data that contains binary integer variables, we first decide to accept or reject real-time dynamic charging requests. Next, the urgency of charging requests determines the priority of each electric vehicle for allocating the multiple autonomous mobile chargers. Lastly, mobile robotic chargers are examined for their battery levels and operational status, whether active or idle, before charging requests are accepted. The actual network of Vienna, Austria, is carried out to verify the generalization and applicability of the proposed charging strategy. Durability and Adaptiveness of the proposed framework to changes in the number of chargers and charging requests are demonstrated by the validation results. The validation results demonstrate the durability and adaptability of the proposed framework to changes in the number of chargers and charging requests. We also demonstrate that the more robot chargers there are, the more calculations are needed to assess charging possibilities. The proposed optimized charging strategy is expected to enhance user satisfaction by efficiently prioritizing and processing charging requests, while also supporting decision-makers in managing charger operational efficiency.

Keywords: Autonomous mobile robotic chargers, Electric vehicles, Charging strategy, Urgency

SESSION E6: Autonomous Vehicles: Acceptance and Perception

# UNDERSTANDING PUBLIC OPINIONS OF AUTONOMOUS VEHICLES IN CHINA: A SOCIAL MEDIA ANALYTICS APPROACH

A. Dongdong (Oliver) FENG [a] and B. Sylvia Y. HE [a*]

[a] *Department of Geography and Resource Management, The Chinese University of Hong Kong, Hong Kong SAR, China*

**Email: sylviahe@cuhk.edu.hk (Corresponding author)*

Public opinions on autonomous vehicles (AV) have been explored extensively by traditional survey-based studies as AV is expected to reshape travel behaviors and drive the transportation system's future. However, few studies understand AV-related opinions using social media features in China, which would have a special meaning in understanding public opinions compared to quantitative survey studies. This study aims to understand public opinion on AV from a social media perspective in China. We collected over 45,010 comments from TikTok and applied emerging text mining technology (i.e., sentiment analysis and semantic analysis) to understand public opinions on AV. The results show that trust and unemployment are the most common issues, mainly contributing to the negative sentiments towards AV. Some people think AV cannot work well with human drivers regarding the complex internal environment (e.g., roads, traffic, weather, emergencies, etc.) and are curious about the responsibilities and reliabilities of riding AV and data security. Besides, the public tends to worry about future employment issues and workers related to AV development. With the deployment of pilot tests of AV in recent years, people have paid more attention to how to use AV and speed apart from financial costs. The findings offer valuable insights to improve the broad deployment of AV and regulations in the smart mobility era.

Keywords: Autonomous vehicles; social media data; public opinion; natural language processing

# THE RIGHT-OF-WAY ASSIGNMENT STRATEGY AT THE INTERSECTION APPROACH UNDER MIXED TRAFFIC: CONSIDERING THE HETEROGENEITY OF HDV DRIVERS' CONFIDENCE IN CAVS

A. Huan WU [a], B. Fang ZONG [a*], C. Meng ZENG [b*] and D. Peixin SHI [c]

[a] *Jilin University, No. 2699 Qianjin Street, Changchun City, Jilin Province, 130012, China*

[b] *College of Engineering, Zhejiang Normal University, 688 Yingbin Road, Jinhua City, Zhejiang*

[c] *General Research and Development Institute, China FAW Corporation Limited*

[*] *Email: wuhuan22@mails.jlu.edu.cn; zongfang@jlu.edu.cn; zengmeng@zjnu.edu.cn (Corresponding author)*

With the surging development of communication and automated driving technology, connected and automated vehicles (CAVs) will coexist with human-driven vehicles (HDV) for a long time in the future. Therefore, the multicommodity nature of traffic will generate two options for the assignment to the right of way at the intersection: can CAVs and HDVs share a lane or should there be a CAV-only lane? This paper considers the heterogeneity of drivers' confidence in CAVs and establishes a car-following model for driving behavior simulation when an HDV follows a CAV, with which it formulates a simulation comparison between setting and not setting up the CAV-only approach. The setting condition for the CAV-only approach and the control measure without it are then proposed to optimize traffic efficiency in intersections, while the influences of CAV penetration and vehicle layout are considered. The simulation results show that when CAV penetration is greater than or equal to 50%, setting up a CAV-only approach can improve traffic efficiency. When all drivers suspect or trust CAVs, the CAV-only approach should be set up when CAV penetration is no less than 40% or 70%, respectively. Moreover, the control measures that enable CAVs to gather at the beginning of the platoon help optimize the efficiency without the CAV-only approach. The results provide a reference for right-of-way assignment and collaborative control at signalized intersections with different levels of CAV permeability and confidence.

Keywords: CAV-only approach, confidence level, car-following, carbon emission, CAV penetration

As at December 7, 2024

# FACTORS AFFECTING THE ACCEPTANCE OF AUTONOMOUS VEHICLES: A CASE STUDY OF SEOUL, SOUTH KOREA

A. Ria Roida MINARTA [a], B. Jonghan PARK [a] and C. Joonho KO [a*]

[a] *Department of Urban and Regional Development, Graduate School of Urban Studies, Hanyang University, Seoul, South Korea*

[*] *Email: jko@hanyang.ac.kr (Corresponding author)*

Autonomous vehicles (AVs) are revolutionizing global transport in terms of technology. As the trend continues, South Korea sets an ambitious target of achieving a 50% market penetration by 2035. This study evaluates the willingness of Seoul commuters to adopt AVs through Latent Class Analysis (LCA) and ordered logit models, analyzing the attitudes and travel behaviors of 1,000 employed residents who use private cars or public transport. The LCA result reveals three primary classes: safety-conscious skeptics, tech-optimistic commuters, and policy- and environment-minded commuters. Safety-conscious skeptics, predominantly older, married, and with children, exhibit significant caution toward AV adoption. In contrast, tech-optimistic commuters—mainly male, private car users, white-collar workers, and higher-income individuals—show a higher openness to AV technology. Policy and environment-minded commuters are mainly concerned with vehicle costs and travel distances. Additionally, segmentation between private vehicle and public transport users revealed similar classifications: safety-conscious skeptics and eco-tech enthusiast commuters. Safety-conscious commuters who do not own cars tend to emphasize safety, likely due to their unfamiliarity with AV technology or heightened expectations from costlier cars. Meanwhile, eco-tech enthusiasts in public transportation show an increased likelihood of adopting AVs when they frequently engage in complex travel schedules involving multiple transfers. These findings provide essential insights into commuter perspectives on AVs, forming a basis for targeted strategies to enhance AV acceptance and integration into urban transport systems.

Keywords: Autonomous Vehicle, Willingness to use, AV adoption, Ordered logit model, Random parameter

# IMPACT OF RISK PERCEPTION AND TRUST IN AUTONOMOUS VEHICLES ON PEDESTRIAN CROSSING DECISION: NAVIGATING THE SOCIAL-TECHNOLOGICAL INTERSECTION WITH THE ICLV MODEL

A. Zhongxiang FENG [a*], B. Ya GAO [a], C. Dianchen ZHU [a] and D. Bin ZHOU [a]
[a] *School of Automobile and Traffic Engineering,*
*Hefei University of Technology, Hefei, Anhui, China*
[*] *Email: fzx@hfut.edu.cn (Corresponding author)*

In the rapidly evolving realm of transportation technology, the dynamic relationship between pedestrians and technological innovations has attained unprecedented importance. The complex social-technological intersection surrounding pedestrian road crossings has emerged as an attention for traffic safety. To investigate how pedestrians perceive risks, trust technology, and make decisions in this era of technological progress, we designed a video-based questionnaire utilizing the stated preference methodology. We collected SP data from 589 Chinese pedestrians and employed an integrated choice (SP) and latent variable (ICLV) model to quantify the influence of risk perception and trust in autonomous vehicle (trust in AV), treated as latent variables, on their crossing decisions. Our findings indicate that the presence of autonomous vehicles significantly affects pedestrian crossing decisions. Specifically, an increase in the approaching vehicle speed and a decrease in the approaching vehicle distance increase the pedestrians' tendency to choose not to cross the road, and the latent variables of risk perception and trust in AV strongly predict this phenomenon. The results of the scenario analysis show that, compared with overall pedestrians, middle-aged pedestrians and high-risk perception-level pedestrians are more conservative in their crossing decisions, but high levels of trust in AV improve pedestrians' willingness to cross the street. Additionally, the pedestrian-related findings of this study at the social-technological intersection provide better understanding of the decision process and contribute to the planning and development of urban intelligent transportation systems.

Keywords: Pedestrian crossing, Autonomous vehicles, Surveillance cameras, Risk perception, Trust

# INVESTIGATING PERCEPTION, CRITICAL SCENARIOS AND TRAINING GAPS FOR AUTONOMOUS DRIVING SYSTEMS – A HUMAN INTERVENTION PERSPECTIVE

A. Z.XU [a] and B. N. ZHENG [a*]
[a] *Department of Civil and Environmental Engineering,*
*Monash University (Clayton), Melbourne, Australia*
[*]*Email:* *nan.zheng@monash.edu*

High-level autonomous driving systems face practical challenge. The existing implementation cases show that the current systems are not sufficiently, and that riders who sit in the vehicles do not trust the operation and thus intervene or take over the operation under certain critical scenarios. It is important to identify the gaps in the existing high-level autonomous driving systems and study those scenarios that riders tend to disagree with the autonomous driving system's decisions. The presented research work aims to develop a human-in-the-loop and VR-simulation enabled research approach to address the aforementioned issue. In particular, it investigates (1) the disparity in risk perception between human and the existing systems, (2) the measurement and characteristics of "critical" scenarios, (3) the association between human intervention and scenario criticality and its consequences, and (4) the necessity of human intervention during high-level autonomous driving systems. Through tens of thousands human-in-the-loop experiments, the presented work highlights the importance of learning from rider or human perspectives on safety improvement for autonomous vehicles, offers alternative views on training enhancement, and provides a tool to carry out autonomous driving system training scenario generation. The presented work has led to a few publications at the top transportation journals including TR-C, TR-D, AAP, IJHCI, IEEE-TIV and Chemosphere.

Keywords: high-level autonomous driving, human intervention, criticality, human-in-the-loop and simulation-based experiments, training enhancement

## SESSION F1: Carbon Emissions in Traffic Management

# GREEN FAMILY VEHICLE ROUTING PROBLEM

A. Chin Sum SHUI [a] and B. Pin-Yin JIANG [a*]
[a] *Department of Transportation and Logistics Management,*
*National Yang Ming Chiao Tung University, Hsinchu City, Taiwan ROC*
**Email: jpy312703001.mg12@nycu.edu.tw (Corresponding author)*

Flexible delivery and storage have been important components in city logistics operations. For a customer (family) with multiple storage spaces (members), it allows all commodities to be delivered to a defined number but not all of its storage spaces. So, the logistic operator can have a more flexible delivery as only part of the members in each family are visited. This paper introduces a novel green family vehicle routing problem (GFVRP) in which the operator aims to determine the optimal vehicle fleet and routes that can minimize the total emission. The delivery per family must be fulfilled using a heterogeneous fleet of vehicles. A novel compact formulation is proposed to model the problem, and strengthening inequalities are introduced to improve the solution search efficiency. Numerical studies demonstrate that the green objective can effectively reduce total emissions compared to the conventional cost minimization objective. Various low-carbon policies are investigated and compared to examine the most efficient measure for reducing emissions. Sensitivity analyses are performed to study the trade-offs between the performance indicators, including capacity utilization, fuel and emissions, and vehicle acquisition costs.

Keywords: family vehicle routing problem, compact formulation, green logistics, emission

# A STUDY ON THE IMPACT OF PERSONAL CARBON ALLOWANCE ALLOCATION AND TRADING ON TRANSPORTATION SYSTEM

A. Yaqi YANG [a] and B. Xiaoning ZHANG [b*]

[a] *Urban Mobility Institute,Tongji University,Siping Road No.1239,Shanghai 200092,China*

[b] *School of Economics and Management,Tongji University,*
*Siping Road No.1239,Shanghai 200092,China*

[*] *Email: yaqi@tongji.edu.cn (Corresponding author)*

This paper explores the potential impacts of a Personal Carbon Allowances (PCAs), which limit the amount of carbon an individual can emit, on commuters' travel mode choices in transportation systems. It represents an attempt to explore how travelers will respond in the face of constraints which might be necessary to support the delivery of rapid decarbonization. The transportation network model deployed consists of a highway represented by a Vickrey bottleneck and a transit line with an affine crowding cost. The study compares traffic congestion levels before and after the introduction of PCAs and assesses the policy's effectiveness in promoting public transportation. Besides, the research employs a Pareto optimization approach to explore the optimal total amount of carbon allowances that balances both effectiveness and fairness. Numerical examples show that carbon allowances distribution and trading policy can effectively reduce car use and direct travelers to public transportation modes. Besides, this study also examines the impact of factors such as road capacity and the level of public transportation development on the effectiveness of the carbon allowance policy.

Keywords: personal carbon allowances, Vickrey model, traffic congestion, transit priority

# MODELLING DYNAMIC SPATIAL-TEMPORAL CARBON EMISSION EXPOSURE WITH HETEROGENEOUS TRAFFIC FLOWS

A. Yaxin WU [a, b*], B. Xiaowei HU [a*], C. Jiyong LIAO [c], D. Yujia WANG [a, d]
and E. Yu JIANG[b, e]
[a] *School of Transportation Science and Engineering,*
*Harbin Institute of Technology, Harbin, 150090, China.*
[b] *Lancaster University Management School (LUMS), Lancaster University,*
*Lancaster, LA1 4YX, United Kingdom.*
[c] *College of Computer Science and Electronic Engineering, Hunan University,*
*Changsha, 410082, China.*
[d] *Department of Aeronautical and Aviation Engineering, Faculty of Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR*
[e] *Department of Management Engineering, Technical University of Denmark,*
*Lyngby, 2800, Denmark.*
**Email: 21b932020@stu.hit.edu.cn; xiaowei_hu@hit.edu.cn (Corresponding authors)*

On-road carbon emissions are a significant risk to public health. They are generated by heterogeneous traffic flows, including private cars and buses in a multimodal urban transportation system. Developing an efficient instrument to mitigate carbon emissions requires quantifying them and their impact on human health. To this end, this study establishes a holistic framework for quantifying carbon emissions and assessing their impact on human health. The framework is composed of two components:1) a multimodal dynamic traffic assignment model for obtaining equilibrated flow distributions, and 2) a Gaussian plume model built upon a multi-category vehicle carbon emission model for assessing the spatial-temporal dispersion and concentration distribution of transportation carbon emission. Numerical studies using a real road network have been conducted to demonstrate the computational performance of the model and to explain the factors that need to be considered when choosing pedestrian paths by comparing single-objective and multi-objective scenarios. The results show that it is possible to simultaneously reduce travel time, carbon emission, and the impact of their exposure by dynamically managing network flows. This provides the basis for transportation system operators to show that multi-objective optimization models and solutions that consider the environment and its impacts on human health are feasible in route choice.

Keywords: Carbon emission exposure; Dynamic traffic assignment; Heterogeneous flows; Multimodal transportation

# CUSTOMIZED COMMUTING BUS ROUTING UNDER CARBON EMISSIONS REGULATIONS

A. Zhongyu SUN [a], B. Jiangbo WANG [b*] and C. Kai LIU [b*]

[a] *School of Infrastructure Engineering, Dalian University of Technology, Dalian, China*

[b] *School of Economics and Management, Dalian University of Technology, Dalian, China*

[*] *Email: Jiangbo_Wang@dlut.edu.cn; liukai@dlut.edu.cn (Corresponding author)*

Transportation is pivotal in daily life and serves as a primary source of global greenhouse gas (GHG) emissions. Governments globally are expeditiously formulating regulatory frameworks to manage carbon emissions with the aim of reducing their environmental footprint. Among these frameworks, carbon pricing (via taxation) and carbon emissions trading are two strategies that have garnered widespread adoption internationally. However, the impact of these carbon management strategies on the operation of demand-responsive transit systems remains uncertain. This study investigates the effects of two mechanisms, carbon pricing and carbon trading, on the route planning of customized bus services, which is a specific form of demand-responsive transit. This study presents the Open Capacitated Low-Carbon Vehicle Routing Problem and constructs a mathematical model targeted at optimizing profits by considering various parameters including fare revenues, fixed operational expenses, fuel costs, and the costs associated with carbon emissions, as well as the financial gains from emission reductions. The results indicate that the carbon emission trading scheme serve as a better incentive for operators of customized bus services to actively diminish their operational carbon emissions. This is due to the fact that escalating prices within the carbon trading market are likely to engender a progressive enhancement in profitability margins. It is essential to maintain the carbon trading price within a specified range to avoid diminishing the efficiency of carbon reduction efforts.

Keywords: customized bus, carbon emission regulation, vehicle routing, carbon emission trading

# APPLICATIONS OF THE AGENT-BASED MODEL TO ESTIMATE THE ENVIRONMENTAL IMPACTS OF CONSTRUCTION ON THE NEIGHBOURHOOD

A. Xiangyi LI [a*], B. Rosana W.M. WONG [a] and C. Becky P.Y. LOO [a]
[a] *Department of Geography, The University of Hong Kong, Hong Kong, China*
**Email: li_xiangyi@connect.hku.hk (Corresponding author)*

This research targets minimizing local environmental impacts of construction, which often require the transportation of materials to the construction sites. Using agent-based modeling (ABM), it examines the environmental consequences of two Hong Kong case studies—one employing Modular Integrated Construction (MiC) and the other traditional cast-in-situ methods. The study simulates the carbon emissions, air pollution, and noise pollution linked with transporting materials, offering detailed spatial and temporal insights. Results indicate that the MiC approach markedly reduces carbon dioxide emissions, harmful pollutants (such as sulfur dioxide, nitrogen oxides, and volatile organic compounds), as well as PM2.5, PM10 emissions, and noise levels compared to traditional methods. This reduction translates into decreased health risks for communities along the transport routes. Per square meter of construction floor area, the MiC project showed a 20.21% drop in carbon dioxide emissions, a 55% reduction in harmful gases, and 49% and 45% decreases in PM2.5 and PM10 emissions, respectively. Noise levels exceeding 70 dB were 99% lower in the MiC project. The overall health impact, measured in DALYs per m² CFA, was 69% less than that of the cast-in-situ method. This study demonstrates that adopting low-carbon construction techniques like MiC substantially contributes to a more sustainable urban environment.

Keywords: modular integrated construction (MiC); material transportation; environmental impact; agent-based modeling (ABM)

## SESSION F2: Rail Transit Demand and Rerouting

# INTEGRATION STUDY OF INDIVIDUAL TRAVEL PREDICTION AND PASSENGER FLOW FORECASTING: BASED ON THE INDIVIDUAL TRAVEL PATTERNS OF RAIL TRANSIT PASSENGERS

A. J. WANG [a*], B. J. ZHAO [a], C. K. LIU [b*] and D. J.b. WANG [b]
[a] *School of Transportation and Logistics, Dalian University of Technology, Dalian 116024, China*
[b] *School of Economics and Management, Dalian University of Technology, Dalian 116024, China*
[*] *Email: wjss1130@163.com; liukai@dlut.edu.cn (Corresponding authors)*

As data collection and computational technologies continue to advance, applications in rail transit have become more diverse and personalized. Modern scenarios now require not only macro-level passenger flow predictions but also the identification of individual travel patterns at a micro level. Personal travel prediction technology enables a shift from passive to proactive personalized transportation. This research focuses on predicting passenger travel demand within rail transit systems. By analyzing travel characteristics across three scales—long-term, periodic, and short-term—the study models individual passenger behavior during any operational hour. To address data imbalance between travel and non-travel instances in the smart card dataset, a generative adversarial network (GAN) was introduced, which successfully rebalanced the dataset. The results demonstrate a high similarity between the GAN-generated synthetic data and the real data. Subsequently, a deep neural network (DNN) was used to create a complex model that captures intricate feature relationships. Evaluation metrics revealed improved model performance as the imbalance ratio decreased. The model achieved an overall accuracy of 93.77%, particularly excelling during peak hours. By integrating personal travel prediction with passenger flow forecasting, this approach introduces a new perspective on demand prediction in rail transit systems from the traveler’s viewpoint. The findings can enhance service levels and efficiency in rail transit and may be extended to other modes of transportation.

Keywords: Rail Transit, Smart Card Data, Travel Prediction, Individual Travel Behavior

# IDENTIFICATION, CATEGORIZATION AND RATIONALIZATION OF METRO PASSENGER REROUTING CHOICES UNDER METRO DISRUPTIONS WITH A HIERARCHICAL UTILITY-BASED ROUTE CHOICE MODEL

A. Kejun DU [a*], B. Enoch LEE [b*], C. Qiru MA [c*] and D. Hong K. LO [a*]

[a] *Department of Civil and Environmental Engineering,*
*The Hong Kong University of Science and Technology, Hong Kong, China*

[b] *Department of Logistics and Maritime Studies,*
*The Hong Kong Polytechnic University, Hong Kong, China*

[c] *Division of Emerging Interdisciplinary Areas,*
*The Hong Kong University of Science and Technology, Hong Kong, China*

[*] *Email: kduab@connect.ust.hk; ceenoch@ust.hk; qmaap@connect.ust.hk; cehklo@ust.hk (Corresponding author)*

Based on the automated fare collection (AFC) data in the Hong Kong MTR system under system disruption, this study proposes a framework to identify affected regular commuters and categorize them into different rerouting choices. The framework analyzes the AFC data around the metro disruption period on the days before, on and after the day of disruption, to reflect the actual passenger rerouting behaviors. This study further corrects the identified passenger rerouting behaviors, considering the random irregular behaviors of unaffected passengers under normal conditions. The multi-modal routing information are aggregated from both inside and outside the metro system from multiple third-party platforms. Finally, based on the aggregated routing information, this study examines the affected passengers' rerouting choices with respect to alternative routes' attributes, rationalizes the extracted patterns and relationships, providing valuable insights for metro system operators to prepare for future disruptions and showing potential in future research with different topics.

Keywords: Passenger Route Choices, Metro Disruptions, Automated Fare Collection (AFC), Utility-Based Route Choice Model, Data Analytics

# FUSING HOUSEHOLD TRAVEL SURVEY AND SMART CARD DATA TO GENERATE SPATIOTEMPORALLY HETEROGENEOUS ACTIVITY SCHEDULES FOR TRANSIT RIDERS

A. Khoa D. VO [a], B. Eui-jin KIM [b], C. Huichang LEE [c] and D. Prateek BANSAL [a, d*]

[a] *Singapore-ETH Centre, Future Cities Lab Global Programme, Singapore Hub, CREATE Campus, Singapore*

[b] *Department of Transportation System Engineering, Ajou University, Republic of Korea*

[c] *Department of Civil and Environmental Engineering, Seoul National University, Republic of Korea*

[d] *Department of Civil and Environmental Engineering, National University of Singapore, Singapore*

[*] *Email: prateekb@nus.edu.sg (Corresponding author)*

This study proposes a novel two-stage data fusion approach that combines household travel survey (HTS) and smart card (SC) data to generate synthetic populations with sociodemographics and activity plans for transit users at high spatiotemporal heterogeneity. In the first stage, clustering on spatiotemporal characteristics of only transit trips is created to align spatiotemporal resolution and attribute information of HTS and SC data. The data fusion process of transit trips is then reformulated into cluster-specific low-dimensional optimization sub-problems to ensure computational traceability. In the second stage, the data fusion result of transit trips, i.e., the connection between sociodemographics and trip information with spatiotemporal characteristics of transit trips, is utilized to generate missing non-transit trips in SC data. The spatiotemporal clustering process is optimized to ensure such distributional consistencies while maintaining a balance between feasibility and heterogeneity of the synthetic population. The case study using the HTS and SC data from Seoul, South Korea shows that the SC data could greatly improve the spatiotemporal heterogeneity with a vast number of unique attribute value combinations in the synthetic population – 27 times higher than the observation in the HTS data. In addition, the data fusion can provide further insights beyond HTS data, which under-states trip chain lengths and non-commute trips but over-states peak-hour travel demands and home/work duration.

Keywords: Data fusion, Smart card data, Spatiotemporal heterogeneity, Activity-based modeling, Activity schedules

# ESTIMATING INTERCITY RAILWAY TRAVEL DEMAND OF A MEGA-CITY REGION: A HYBRID MULTI-SOURCE DATA-DRIVEN AND MODEL-DRIVEN APPROACH

A. Zijian WANG [a], B. Kai QU [a], C. Xiangdong XU [a*], D. Chao YANG [a], E. Li GUO [b] and F. Jiaqi HU [b]

[a] *The Key Laboratory of Road and Traffic Engineering of Ministry of Education; Urban Mobility Institute, Tongji University, Shanghai 201804, China*

[b] *Shenzhen Planning & Land Research Center, Shenzhen, Guangdong 518040, China*

[*] *Email: xiangdongxu@tongji.edu.cn (Corresponding author)*

Mega-city regions usually become economic centers, whose development relies on intercity railway networks. O-D matrix is a basic data for the network planning and management. Existing studies focus on the station-to-station O-D matrix, while railway is not door-to-door and travelers may use intracity travel modes after alighting at a station. To corporately develop intercity railway and intracity modes, it is necessary to obtain the zone-to-zone O-D matrix, which considers both intercity railway and intracity modes as a whole trip chain and reveals the origin and destination zones of the trip chain. However, there is lack of data to directly identify this O-D matrix, as each possible data source (e.g., railway ticket booking data, and mobile phone data) is insufficient to provide the whole traces of all travelers. Motivated by these observations, this paper proposes a hybrid multi-source data-driven and model-driven approach to estimate the zone-to-zone O-D matrix. Specifically, despite that both the railway ticket booking data and mobile phone data are flawed, their complementary advantages motivate us to develop a tailored data-driven O-D estimation approach by integrating these two data sources. To further improve the estimation quality, a traffic assignment model-driven approach is provided to modify the O-D estimation result by using Bayesian inference. Case studies are conducted in the intercity railway network of Guangdong-Hong Kong-Macao Greater Bay Area. Results indicate that the estimated O-D matrix is explainable, and the hybrid approach is especially effective for O-D pairs with large travel demand but small penetration rate of mobile phone data.

Keywords: travel demand estimation, mega-city region, intercity railway network, Guangdong-Hong Kong-Macao Greater Bay Area

# MODELLING THE EXPECTED PERFORMANCE OF URBAN RAIL TRANSPORT OPERATIONS FOR BENCHMARKING

A. Kai Yi Song, ANUPRIYA [a*] and B. Daniel J. GRAHAM [a]
[a] *Department of Civil and Environmental Engineering,*
*Imperial College London, South Kensington, London SW7 2AZ, UK.*
**Email: anupriya15@imperial.ac.uk (Corresponding author)*

Urban mass transit (metro) systems generate large volumes of data on various aspects of operations. Benchmarking analyses seek to summarise and present such data, drawn from across multiple systems to identify best practice. The process provides a baseline for further examination into the key performance indicators (KPIs), and a data-driven method to prioritise and distribute resources to different areas of improvements in a system offering insights that can drive strategies and policies within the group of systems benchmarked. Nevertheless, the traditional benchmarking process suffers from certain deficiencies, particularly with respect to the usefulness of benchmarking results across different groups of performers. Top performers would generally be above the curve for most KPIs and as such would gain little information for further improvements to their system. Another key pitfall involves tunnel visioning on emulating strategies and practices of top operators without considering the unique contextual factors that influence these decisions. While normalising techniques are commonly employed in benchmarking to contextualise data and allow fair comparisons to be made, these techniques are often limited in their ability to account for heterogeneity in background characteristics of the system that determine their performance. This study seeks to advance the traditional benchmarking methodologies by addressing the problems raised above. Drawing upon the idea of counterfactuals in causal inference, the study constructs a novel 'synthetic' unit to predict the expected performance for each metro system given the background characteristics and features relevant to each metro system. It thus delivers an innovative 'personalised' benchmark for each system.

Keywords: urban rail transit, performance measurement, benchmarking

SESSION F3: Demand-Responsive Transport Services

# WHAT DO WALKING AND E-HAILING BRING TO SCALE ECONOMIES IN ON-DEMAND MOBILITY?

A. Kenan ZHANG [a], B. Javier ALONSO-MORA [b] and C. Andres FIELBAUM [c*]
[a] *School of Architecture, Civil and Environmental Engineering, EPFL*
[b] *Department of Cognitive Robotics, Delft University of Technology*
[c] *School of Civil Engineering, University of Sydney*
[*] *Email: andres.fielbaum@sydney.edu.au (Corresponding author)*

This study investigates the impact of walking and e-hailing on the scale economies of on-demand mobility services. An analytical framework is developed to i) explicitly characterize the physical interactions between passengers and vehicles in the matching and pickup processes, and ii) derive the closed-form degree of scale economies (DSE) to quantify scale economies. The general model is then specified for conventional street-hailing and e-hailing, with and without walking before pickup and after dropoff. We show that, under a system optimum fleet size, the market always exhibits economies of scale regardless of the matching mechanism and the walking behaviors, though the scale effect diminishes as passenger demand increases. Yet, street-hailing and e-hailing show different scale economies in their matching process. While street-hailing matching shows a constant DSE of two, e-hailing matching is more sensitive to demand and its DSE diminishes to one when passenger competition emerges. Walking, on the other hand, has mixed effects on the scale economies: while the reduced pickup and in-vehicle times bring a positive scale effect, the extra walking time and possible concentration of vacant vehicles and waiting passengers on streets negatively affect scale economies. All these analytical results are validated through agent-based simulations on Manhattan with real-life demand patterns.

Keywords: passenger-vehicle matching, on-demand mobility service, scale economies, walking

# ONLINE OPERATIONS OF A MIXED-FLEET RIDE-HAILING SERVICE SYSTEM CATERING TO SPECIALIZED NEEDS OF SENIORS

A. Xindi TANG [a,d], B. Xiaozhuang LI [b], C. Fang HE [b] and D. Yang LIU [c,d*]

[a] *School of Management Science and Engineering, Central University of Finance and Economics, Beijing 100081, P. R. China*

[b] *Department of Industrial Engineering, Tsinghua University, Beijing 100084, P. R. China*

[c] *Department of Civil and Environmental Engineering, National University of Singapore, Singapore 117576, Singapore*

[d] *Department of Industrial Systems Engineering and Management, National University of Singapore, Singapore 117576, Singapore*

**Email: thutxd@gmail.com (Corresponding author)*

The growing trend of an aging population, coupled with increasing demand for personalized mobility services, has led to the development of diverse hybrid mobility systems. This study focuses on a mobility service that integrates both specially equipped and regular vehicles to cater to senior and regular passengers. Senior passengers, who often require specially equipped vehicles, plan their trips in advance and make pre-booked reservations, while regular trip requests are accommodated on an ad-hoc basis. We propose a Chaining-Conducting-Matching Relocation hierarchical framework to manage the online operations of this system, chaining senior passengers' orders into optimized trip sequences and optimizing specialized relocation and order-matching strategies for both types of vehicles. The problem is approached using a learning-driven optimization method, further enhanced during the preparation phase by adaptive large neighborhood search (ALNS). This integrated approach mitigates short-sightedness decision-making and enhances long-term and global rewards, achieving efficient service with a limited number of vehicles and capacity replenishment. Based on the New York City taxi dataset, this paper validates the effectiveness of our proposed framework and algorithms and derives managerial insights.

Keywords: Senior mobility; Learning-and-optimization; Reservation; Online operations; Adaptative large neighborhood search

# PRICING STRATEGIES IN DEMAND-RESPONSIVE TRANSPORT SERVICES

A. Wee Meng YEO [a*]
[a] *School of Management, Adam Smith Business School, University of Glasgow, Scotland, United Kingdom*
**Email: WeeMeng.Yeo@glasgow.ac.uk (Corresponding author)*

This industrial case study arises out of a project "Pricing and Incentives for New Transport Solutions in Towns and Small Cities", where we partnered with a U.K-based social enterprise rolling-out ridesharing services in areas characterised by low income, poor availability of public transport and/or requiring a long time to access essential services. Using a range of methodologies (survey and econometric modelling), the goal is to understand key market levers on profitability. There is an interplay of factors such as potential market size, competition dynamics, passengers' willingness-to-pay (WTP), where we explore how profitability can be sustained without compromising on ride affordability. During presentation, we will also explain how the spreadsheet is being deployed, allowing the user to test the profitability impact of various pricing policies. We also hope to share learnings and reflections from all key stakeholders in this academic-industry collaborative project.

Keywords: Transport poverty, future of mobility, pricing strategy

# CLASSIFYING PERFORMANCE LEVEL OF DEMAND RESPONSIVE TRANSPORT SERVICES IN TAIWAN: A CONTEXT-DEPENDENT DATA ENVELOPMENT ANALYSIS

A. Barbara T.H. YEN [a*], B. Corinne MULLEY [b], C. Shuo-Chen HSIEH [c]
and D. Yu-Wen PAI [d]
[a] *Department of Transportation and Logistics Management,*
*National Yang Ming Chiao Tung University, Taiwan*
[b] *Institute of Transport and Logistics Studies,*
*The University of Sydney Business School, Australia*
[c] *National Yunlin University of Science and Technology, Taiwan*
[d] *Institution of Transportation, MOTC, Taiwan*
**Email: barbarathyen@nycu.edu.tw (Corresponding author)*

Demand responsive transport (DRT) services have become popular to provide public transport to rural areas. A critical issue in providing a DRT service is how to operate the service in more efficiently, provide enhanced performance and have less dependence on subsidy. Most DRT services are heavily subsidised and DRT services in Taiwan are no exception. This paper aims to measure the route-based performance of DRT services in Taiwan with a context-dependent data envelopment analysis (DEA) approach to produce a ranking level of the performance of different DRT services. The results show that in Taiwan, there are seven performance levels for DRT services and that those routes in low financial level counties have better performance since those DRT services have been designed as the main public transport option to access main city areas. This paper concludes with the policy applications of how to improve route performance for each performance level.

Keywords: DRTS, Demand Responsive Transport Services, Data Envelopment Analysis, Context-dependent Data Envelopment Analysis, DEA, Performance Evaluation, Public Transport

# CONSUMER ENGAGEMENT AND THE ADOPTION OF EMERGING SUSTAINABLE TRANSPORT OPTIONS IN CHINA AND DENMARK

A. John THØGERSEN [a*] and B. Ting ZHANG [b*]

[a] *Aarhus University, Department of Management, Denmark*

[b] *Department of Business Administration, Guangdong University of Finance, China*

[*] *Email: jbt@mgmt.au.dk; zhangtina0512@foxmail.com (Corresponding author)*

Consumer engagement attracts increasing attention across the behavioral sciences. However, research on consumer engagement in environmental issues has been lacking behind. Here, we study the impact of consumer's environmental engagement for their willingness to adopt new, more sustainable transport options. Representative samples of residents of China (N=500) and Denmark (N = 619) were surveyed on behavioral engagement (past pro-environmental behavior), attitudinal engagement (pro-environmental self-identity) and intentions to engage in "green" leisure travel activities and to buy an electric car. Structural equation modelling was used to analyze the data. After controlling for past travel mode choices (public transport and cycling), past engagement in pro-environmental behavior increases the willingness to engage in new, more sustainable transport behaviors, partly mediated through and amplified by attitudinal engagement in both China and Denmark. Companies and policymakers can use these findings to develop communication to encourage sustainable transport behavior, benefitting society, environment, and companies.

Keywords: Consumer engagement, behavioral spillover, self-identity

SESSION F4: Emergency and Crisis Response Management

## DYNAMIC RECONFIGURATION STRATEGIES FOR MANAGING SHELTER AND ROAD CONGESTION IN URBAN EMERGENCY EVACUATIONS

A. S. MASUDA [a] and B. E. HATO [a*]

[a] *Department of Civil Engineering, The University of Tokyo, Japan*

[*] *Email: hato@bin.t.u-tokyo.ac.jp (Corresponding author)*

Road and shelter congestion during urban emergency evacuations can lead to failures or cancellations of evacuation. While many studies have independently focused on either shelter or road congestion during disasters, this study examines the interplay between them and manages both as a unified system. Since evacuees cannot enter crowded shelters and must cruise for alternatives on the road network, congestion in shelters directly impacts road congestion. We model horizontal road congestion using the Macroscopic Fundamental Diagram (MFD) and a dynamic evacuation behavior model. The evacuation success rate function then links horizontal road congestion to vertical shelter congestion. To alleviate road congestion, we dynamically manage and reconfigure shelter occupancy by dispatching evacuees from crowded shelters to vacant ones. The proposed dynamic reconfiguration of shelter occupancy is formulated as a nonlinear optimal control problem, considering both horizontal and vertical traffic dynamics, and solved using model predictive control. The results demonstrate that the optimal dynamic reconfiguration strategy dispatches evacuees from regions with low shelter capacity and high evacuation demand to outskirt regions with lower evacuation demand. This control reduces the number of vehicles cruising for shelters and those moving toward their destinations, thereby reducing road congestion.

Keywords: dynamic reconfiguration, MFD, evacuation, model predictive control

# ROBUST LOCATION FOR QUARANTINE FACILITIES UNDER DECENTRALIZED ROOM ASSIGNMENT: A BI-LEVEL MIXED-INTEGER PROGRAMMING APPROACH

A. Yuhao LIU [a,b,c] ,B. Zhibin CHEN [a,b*] and C. Joseph Y.J. CHOW [c]

[a] *Shanghai Frontiers Science Center of Artificial Intelligence and Deep Learning, NYU Shanghai, Shanghai, China*

[b] *Shanghai Key Laboratory of Urban Design and Urban Science, NYU Shanghai, Shanghai, China*

[c] *C2SMARTER University Transportation Center, Department of Civil and Urban Engineering, New York University, Brooklyn, NY, United States.*

**Email: zc23@nyu.edu (Corresponding author)*

Centralized quarantine has been proven an effective counter-pandemic measure. However, the design of quarantine facility location and allocation remains challenging because it should strike a balance among costs, cross-infection risk and public acceptance. In this study, we consider the quarantine facility location problem where different arrival nodes (e.g., airports, railway stations, etc.) are allocated with different groups of designated quarantine hotels (DQHs) to reduce the cross-infection risk while public acceptance is maintained by allowing inbound travelers to choose any available rooms in the DQHs. Under some mild assumptions on travelers' room choice behavior, we first mathematically derive a novel equilibrium condition to model all possible outcomes of the decentralized room assignment. Due to the non-uniqueness of the equilibrium, we then develop a robust quarantine facility location model which optimizes the worst-case scenario. The model appears as a bi-level mixed-integer program (BMIP), in which the government decides the DQH location and allocation in the upper level to minimize the total cost, while inbound travelers in the lower level make their room choices to maximize the government's objective. To solve the proposed BMIP on large-scale problems, we design an iterated local search (ILS) algorithm. Numerical results show that the ILS algorithm outperforms the state-of-the-art BMIP solver and a column-and-row-generation-based exact algorithm given a 2-hour running time limit. Finally, we conduct a case study based on the data published by the Hong Kong government. The result suggests that the proposed model can significantly decrease the cost variation due to decentralized room assignment.

Keywords: location, quarantine facility, user equilibrium, decentralized assignment, robust optimization

As at December 7, 2024

# CAUSAL ANALYSIS OF THE IMPACT OF TELEWORK DURING COVID-19 ON ACTIVITY CHOICE BEHAVIOR IN TOKYO

A. Ryuhei KURASAWA [a], B. Eiji HATO [a*] and C. Xiao FU [b]
[a] *Department of Civil Engineering, The University of Tokyo, Japan*
[b] *School of Transportation, Southeast University, China*
[*] *Email: hato@bin.t.u-tokyo.ac.jp (Corresponding author)*

The spread of COVID-19 has forced many workers to change the focus of their activities from the office to their homes. In general, telework continued in many countries after the pandemic, so it is essential to consider the impact of telework to predict future behavior of residents. The investigation of the impact of telework on non-work activity choice behavior represents a critical research avenue; however, the existing literature in this area remains insufficient. In this paper, we use longitudinal probe-person survey data before and after the COVID-19 pandemic in Tokyo to determine the long-term effects of telework on workers' non-commuting activities. Focusing on travel frequency and activity time allocation, we use the difference-in-differences method to extract and discuss only the changes due to telework from changes in activity during the COVID-19 pandemic caused by various factors. The results show that telework increases the number of activities near home on weekdays and decreases the time spent per activity. Furthermore, an analysis of teleworkers' time allocation using a discrete-continuous model revealed that fixed activity location and a decrease in the heterogeneity of individuals' time consumption patterns have occurred. Teleworkers' weekday activities have changed to focus more on activities necessary for daily life than before the introduction of telework. This may have resulted in homogenizing activity locations and time consumption behaviors.

Keywords: telework, MDCEV model, difference-in-differences, activity-choice behavior, panel data

# CRITICALITY ROAD SEGMENT IDENTIFICATION FOR ENHANCING POST-EVENT NETWORK EFFICIENCY THROUGH GRAPH ATTENTION NETWORKS

A. Yitao YAO [a], B. Bin JIA [a*] and C. Tingting ZHAO [a*]
[a] *School of Systems Science, Beijing Jiaotong University, Beijing, China*
[*] *Email: bjia@bjtu.edu.cn; ttzhao@bjtu.edu.cn (Corresponding authors)*

Identifying key road segments and prioritizing their protection to enhance the resilience of road networks against crisis events is an ongoing challenge. Traditional methods for identifying key road segments have often overlooked the interactions and collaborative relationships among multiple segments, i.e., the analysis of the impact of simultaneous failures on the overall network performance. To address this issue, this paper proposes a road network critical segment identification model based on Graph Attention Networks, named Transportation GAT model for Criticality Analysis (TGAT-CA). This methodology leverages graph attention networks to explore the interacting weights between road segments and calculates the criticality values of each segment based on these weights, enabling the identification of key segments in the road network. Taking the Anaheim road network as an example, the TGAT method is compared with three other methods, namely, Degree Centrality, Weighted Betweenness Centrality, and Eigenvector Centrality, in identifying important segments in the network. The performance comparison is conducted through extreme failure scenario generation and node-by-node deletion experiments. The results demonstrate that TGAT outperforms the other three methods in identifying key road segments. Moreover, in terms of fine-tuning the learning rate, the Cosine-Annealing-LR strategy proves more effective than the Step-LR strategy in the training of the TGAT model for identifying critical road segments.

Keywords: Road network, Multiple-link disruption, Criticality analysis, Importance ranking, Machine Learning

# RIPPLE EFFECT OF AMMONIA SUPPLY DISRUPTION ON THE AMMONIA BUNKER SUPPLY CHAIN

A. Mengyao YANG [a, b*] and B. Jasmine Siu Lee LAM [c*]

[a] *School of Civil and Environmental Engineering, Nanyang Technological University, Singapore*

[b] *Maritime Energy and Sustainable Development Centre of Excellence, Nanyang Technological University, Singapore*

[c] *Department of Technology, Management and Economics, Technical University of Denmark, Denmark*

[*] *Email: mengyao001@e.ntu.edu.sg; jasmlam@dtu.dk (Corresponding author)*

Ammonia is one of the alternative marine fuels to reduce greenhouse gas emissions for international shipping and reduce the impact of maritime transportation on climate change. The uncertainties in its supply chain, such as low-frequency and high-impact disruption, can impact the system performance, affecting the parties served in the supply chain. This paper analyses the ripple effect of ammonia supply disruption on the ammonia bunker supply chain, considering ammonia bunker demand dynamics. A Coloured Petri Nets model is developed to evaluate the changes in system performance and risk mitigation strategies.

Keywords: Ammonia, Disruption risk, Bunker supply chain, Petri Nets, Ripple effect

## SESSION F5: Urban Air Quality and Transportation

### DID A TRANSFORMATIVE PUBLIC TRANSPORT INVESTMENT IMPROVE AIR QUALITY? ELIZABETH LINE IN LONDON

A. Liang MA [a*], B. Kai COOPER [b], C. Marc E.J. STETTLER [a] and D. Daniel J. GRAHAM [a]
[a] *Centre for Transport Engineering and Modelling, Department of Civil and Environmental Engineering, Imperial College London, UK*
[b] *The Wharton School, University of Pennsylvania, U.S.*
**Email: liang.ma13@imperial.ac.uk (Corresponding author)*

Public transport is commonly connected to benefits such as reducing traffic congestion and improving air quality. The Elizabeth Line, introduced in 2022, represents the most significant single increase in London's transport capacity in over 70 years. Connecting surrounding cities, a major airport, and central employment centres, this line is anticipated to increase the rail capacity in central London by 10%. Using meteorological normalisation for confounding control, repeated change point detection for response identification via hypothesis testing, and a regression discontinuity design for causal inference, our study finds heterogeneous responses in air pollution across different places in London. Changes in $NO_2$ concentrations ranged from -9% to 0% in the short run and -15% to 0% in the long run. Greater reductions in roadside pollution were typically observed in central London and near busy stations. Our findings highlight the potential of public transport improvements in mitigating air pollution while emphasising the importance of accounting for the spatial heterogeneity of effects.

Keywords: Air Pollution; Causal Analysis; Elizabeth Line; Public Transport; Structural Change.

# SUBWAY EXPANSION, ROAD CONGESTION, AND URBAN AIR QUALITY

A. Xiaolong LI [a, b*], B. Xiaowen FU [c] and C. Daqing GONG [b]
[a] *Department of Industrial and Systems Engineering, Hong Kong Polytechnic University, Hong Kong, China*
[b] *School of Economic and Management, Tongji University, Shanghai, China*
[c] *Behavior and Knowledge Engineering Research Centre, Department of Industrial and Systems Engineering, Hong Kong Polytechnic University, Hong Kong, China*
[*] *Email: xiaol.li@connect.polyu.hk (Corresponding author)*

Subway expansion has become an important urban transportation strategy to address traffic congestion and air pollution in many cities, however, many issues are yet to be explored concerning the mechanism behind this impact. Therefore, in addition to the analysis of the direct impact of the new subway station on air pollution, this paper also examined the indirect impacts of the subway on air pollution by changing road traffic. Using a 3SLS approach and subway smart card data, the paper examines both the short-term and long-term effects of subway development on traffic congestion and air pollution. The results show that in the short-term, the opening of new subway lines did not have a significant direct impact on air quality or road congestion. In the long-term, however, road congestion is positively associated with air pollution, while increases in subway ridership were found to have a nonlinear effect on road congestion. More importantly, further analysis of the mediation effects reveals the statistical significance of the indirect effect. The subway system significantly reduces air pollution in the surrounding area by significantly alleviating road congestion in the long-term. These findings provide new insights into the mechanisms linking urban rail transit, urban road traffic and urban sustainability, highlighting the complex interaction between urban transportation infrastructure, traffic patterns, and environmental outcomes. It suggests that to maximize the air quality benefits of subway expansion, policymakers should carefully manage subway capacity and usage to avoid excessive congestion around stations.

Keywords: subway expansion, road congestion, air quality, mediation effect

# AIR POLLUTION AND TRAVEL TO SCHOOL – PART I: A THEORETICAL BI-MODAL SCHOOL TRIP MODEL

A. Kim N. DIRKS [a*], B. Judith Y.t. WANG [b*] and C. Matthias EHRGOTT [c]
[a] *Department of Civil and Environmental Engineering, University of Auckland, New Zealand*
[b] *School of Civil Engineering and Institute for Transport Studies, University of Leeds, U.K.*
[c] *Department of Management Science, Lancaster University, U.K.ABC Corporation, U.K.*
[*] *Email: k.dirks@auckland.ac.nz; j.y.t.wang@leeds.ac.uk (Corresponding authors)*

Promoting modal shift from being driven to school to walking has received a high level of attention from transport authorities around the world and the task has been proved challenging. Most studies have looked at the potential benefits of the increase in physical exercise but no studies exist looking at the benefits of reduction in pollutant dose induced by the modal shift specifically from being driven to walking. We propose a theoretical bi-modal school trip model to analyse the interplay of mode choice, i.e. being driven or walking to school, the environment (air quality) and the impact on the health of children (dose). The air quality assessment is dependent on the traffic speed and associated traffic density during the journey, which is a result of the mode choices of the pupils as well as the location of the school. We considered two cases of school location: at a cul-de-sac and on a busy road. We show how the pollutant dose will be dependent on both the level of background traffic and the school-specific traffic at different locations. With this theoretical model, it is possible to assess the extent to which we can achieve benefits from walking to school and what conditions would be needed for there to be any benefit from the point of view of the dose experienced by the school's children in the course of their commute. Our model results provide insights into what policies under what conditions benefits from walking to school could be achieved.

Keywords: Walking School Bus, School travel, Transport mode choice, Sustainability mobility, Air pollution exposure

# AIR POLLUTION AND TRAVEL TO SCHOOL – PART II: A CLOUD-BASED SMART APP FOR WALKING SCHOOL BUSES

A. Timothy J. AMSDON [a*], B. Judith Y.t. WANG [b*], C. Jin LIU [c] and D. Edward BROWN [d]

[a] *School of Electronic and Electrical Engineering, University of Leeds, U.K.*

[b] *School of Civil Engineering and Institute for Transport Studies, University of Leeds, U.K.*

[c] *Institute for Transport Studies, University of Leeds, U.K.*

[d] *School of Civil Engineering, University of Leeds, U.K.*

[*] *Email: t.j.amsdon@leeds.ac.uk; j.y.t.wang@leeds.ac.uk (Corresponding authors)*

For the last four decades, there has been a considerable modal shift from walking to school to being driven for school trips in the U.K. One effective counteractive initiative has been the introduction of walking school buses (WSB) which involves a group of children walking to school, supervised by one or more adults and following a set route. However, in the choice of walking routes, little attention is given to the differences in air pollution exposure that would be experienced. The purpose of this project is to develop a prototype for a smart app to promote safe walking to school along planned WSB routes optimised based on multiple objectives: (1) minimise travel time; (2) minimise pollutant dose; and (3) maximise walkability. The use of the app will help optimise the operational efficiency and management of WSBs, while maintaining the highest level of personal information security. For this purpose, a cloud-based system has been designed with state-of-the-art technologies connected with the school, WSB planners and operators, parents and children. Through the use of mobile phone apps with different functionality made accessible to parents and WSB drivers, and connected to wearable devices worn by children, the operational efficiency and safety can be maintained at the highest level, generating maximum benefits for society. Ultimately, this will help turn a vicious cycle of children being chauffeured to school (with consequent Net Zero and Public Health disbenefits) to a virtuous cycle of accompanied walking to school using safe and ultimately, cleaner and more enjoyable routes.

Keywords: Walking school bus, School travel, Sustainable mobility, Air pollution exposure, Cloud-based smart App

# ASSESSING ZERO-EMISSION BUS MARKET IN HONG KONG FROM A LIFECYCLE PERSPECTIVE

A. Zhuowei WANG [a*], B. An WANG [a], C. Anthony CHEN [a] and D. Hongxing YANG [b]
[a] *Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, China*
[b] *Department of Building Environment and Energy Engineering, The Hong Kong Polytechnic University, China*
**Email: zhuowei.wang@connect.polyu.hk (Corresponding author)*

Hong Kong (HK) is actively pursuing carbon neutrality in the transport and energy sectors. A key strategy in public transit is the introduction of zero-emission buses (ZEBs), including hydrogen buses (H-buses) and battery electric buses (E-buses). While ZEBs produce no tailpipe emissions, their fuel-cycle emissions depend on the upstream energy sectors. This dependence necessitates a holistic consideration of the transport and energy sectors to assess the ZEB market and determine the appropriate energy mix during the transition to carbon neutrality. This study conducts a comprehensive lifecycle assessment (LCA) of the ZEB market in HK's unique context. We adopt a common framework of fuel-cycle analysis, accounting for well-to-wheel emissions of electricity and hydrogen from various primary energy sources (e.g., nuclear, coal, natural gas, solar, wind, and waste). We then test various scenarios of energy mix and pathway options to assess the environmental impacts of ZEB market development in HK. The results show that under the current HK energy condition, E-buses (6.50g CO2e/ passenger-km) perform better than H-buses (12.20g CO2e/passenger-km) in fuel-cycle emissions. However, H-buses exhibit significant potential for future carbon emission reduction. Accordingly, the study suggests policy recommendations such as developing renewable energies, prioritizing carbon capture and storage (CCS), advancing local hydrogen production technologies, and promoting electrolysis only within a carbon-free electricity system. These insights could assist policymakers in achieving a cost-effective and eco-friendly ZEB transition in HK from an integrated perspective.

Keywords: Hydrogen bus; Battery electric bus; Energy mix; Fuel-cycle emissions; Lifecycle assessment

## SESSION F6: Electric Vehicle Adoption and Infrastructure

# IMPACT OF ELECTRIC VEHICLE PROMOTION ON CARBON EMISSIONS FROM PASSENGER CARS UNDER DIVERSE POLICY SCENARIOS

A. Peimin WU [a], B. Xuan MA [a] and C. Xiao FU [a*]
[a] *School of Transportation, Southeast University, Nanjing, China*
[*] *Email: fuxiao@seu.edu.cn (Corresponding author)*

The widespread adoption of electric vehicles (EVs) has substantially transformed the emissions inventory of passenger cars. Accurately quantifying the changes in carbon emissions before and after EV promotion, along with predicting their impact on the passenger car market under various policy scenarios, is essential for evaluating the effectiveness of EV introduction and for identifying sound policy measures. However, the traditional bottom-up approach, which estimates carbon emissions primarily based on vehicle miles travelled (VMT), often neglects vehicle activity data, thereby compromising the accuracy of emission factor (EF) calculations. To overcome these limitations, this study examines the temporal dynamics of EV promotion, assesses changes in passenger vehicle composition and stock, and calculates EFs using vehicle activity data within the COPERT model. By integrating VMT and fuel/energy consumption data, the study simulates the evolution of carbon emissions from passenger cars in Shanghai over recent years. Furthermore, future vehicle emission inventories are projected under a baseline scenario and two real emission reduction policy scenarios, with comparative analyses conducted to evaluate their potential impacts. The spatial distribution of passenger car emissions is also visualized at both the city scale and road level. This study provides critical insights for government agencies in developing EV-related policies, supporting a just transition towards low-carbon travel and the achievement of sustainable transport.

Keywords: electric vehicles, passenger cars, vehicle carbon emissions, emission reduction policies, spatial distribution

As at December 7, 2024

# INNOVATIONS IN THE ELECTRIC VEHICLE INDUSTRY: INSIGHTS FROM TWO DECADES OF PATENT DATA

A. Zhixuan LI [a] and B. Becky P.Y. LOO [a*]

[a] *Department of Geography, The University of Hong Kong, China*

**Email: bpyloo@hku.hk (Corresponding author)*

Electric vehicles (EVs) have gained increasing attention due to their significant potential in transport decarbonization. Despite the ambitious promotion of EVs in many countries and regions, a significant barrier is that the EV technology is still at a developmental stage compared to traditional internal combustion engine vehicles. Continued technological advancement is a crucial pathway to make EVs more widely available and affordable. However, which countries and regions are leaders in EV innovations and how this relates to locational factors is largely unknown. Generally, EV innovations can be classified into three main types related to the battery, electric motor, and vehicle control systems. This study uses more than two decades of patent data to measure EV innovation capacity at the regional level in the United States, Europe and China. It builds a Panel Vector Autoregression (PVAR) model to examine the relationships between three types of EV innovations with various locational factors related to natural resources, industrial structure, and talents. To the best of our knowledge, this is the first study to build an analytical framework with feedback loops to explore the mutual interaction of innovation and locational factors over time. The results show that innovation in electric motor has obvious resource dependence characteristics. EV manufacturing industry agglomeration is beneficial to innovations in the sector. While EV innovations in vehicle control systems attract related firms to expand the industry locally, innovations in the EV battery and electric motor tend to consolidate the dominance of local firms.

Keywords: Electric vehicles; electric vehicle technology; regional innovation capabilities; industrial agglomerations

**PUBLIC ACCEPTANCE AND ADOPTION OF ELECTRIC MOBILITY DEVICES FOR LAST-MILE TRAVEL IN HONG KONG**

A. Jin WANG [a], B. R.c.p. WONG [a*] and C. W.y. SZETO [a]
[a] *Department of Civil Engineering, The University of Hong Kong, Hong Kong*
[*] *Email: cpwryan@hku.hk (Corresponding author)*

Electric Mobility Devices including electric bikes and electric scooters have gained popularity worldwide as environmentally friendly alternatives to conventional modes of transportation for last-mile travel. The Hong Kong Government is planning to legalize their usage along cycle tracks with a speed limit. To determine the feasibility of this scheme, it is crucial to investigate the public acceptance and adoption of electric mobility devices. In this study, an on-site questionnaire was conducted to gather data, which was then utilized to develop a structural equation model and a multinomial logit model. The results indicate that perceived ease of use, facilitating conditions, social influence, and government policy are favorable factors that increase the intention to use electric mobility devices. Furthermore, travel time, walk time, and road congestion level significantly influence the decision to use electric mobility devices for last-mile travel. Based on these findings, several suggestions are provided to enhance public acceptance of electric mobility devices, and promote their usage for a more sustainable and efficient transport system.

Keywords: Electric mobility devices, Last-mile travel, Structural equation model, Multinomial logit model

# OPTIMIZING BATTERY SWAPPING AND BIKE REPOSITIONING STRATEGIES FOR ELECTRIC BIKE-SHARING SYSTEMS

A. Jia CUI [a*] and B. W.Y. SZETO [a, b*]

[a] *Department of Civil Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong*

[b] *The University of Hong Kong Shenzhen Institute of Research and Innovation, Shenzhen, China*

**Email: cuijia@connect.hku.hk; ceszeto@hku.hk (Corresponding author)*

Electric bike-sharing systems are witnessing remarkable growth as low-carbon transportation, functioning as a complementary solution to private cars for "short-to-medium-distance" journeys. However, the availability of the e-bike is constrained by its battery status, as the battery may be depleted after usage. Battery swapping enables rapid function restoration of low-battery e-bikes. By installing fully charged batteries in low-battery e-bikes while recycling depleted batteries, the service functionality of e-bikes can be quickly restored. Although battery swap has emerged as a widely used paradigm, to the best of our knowledge, there is no research on simultaneous e-bike rebalancing and battery swapping for low-battery e-bikes in an EBSS using the same vehicle. This study examines a novel multi-vehicle e-bike repositioning problem, addressing the simultaneous rebalancing of e-bikes and battery swapping for low-battery e-bikes using the same vehicle. A mixed integer linear programming model is proposed with the objective of minimizing the total repositioning cost. Several properties of the studied problem are explored through numerical experiments.

Keywords: Shared mobility; Electric bike-sharing system; Mixed Integer Programming; Battery swapping; Green Transportation

# GREEN SERVICE OPERATIONS FOR ELECTRIC-VEHICLE BATTERY SWAPPING AND CHARGING MODES

A. Si-Rui HONG [a*] and B. Jiuh-Biing SHEU [a]

[a] *Department of Business Administration, National Taiwan University,*
*Taipei 10617, Taiwan, ROC*
**E-mail: d09741011@ntu.edu.tw (Corresponding author)*

This work presents game-theoretical models to address the issue of end-of-life (EOL) battery recycling in the electric vehicle (EV) market under government interventions. Specifically, we establish a Hotelling model of a competitive market consisting of a charging-mode EV manufacturer and a swapping-mode EV manufacturer. The unique feature of the battery-swapping service mode is that the service provider retains ownership of the batteries through battery rental services, significantly facilitating the recycling of EOL batteries. Furthermore, this work investigates the impact of government intervention in EOL battery recycling under EV charging and swapping markets. Three scenarios are proposed and compared: no policy intervention, manufacturer recycling subsidy, and consumer purchase subsidy. Analytical results indicate that government interventions can significantly increase the battery recycling rate and improve social welfare.

Keywords: Electric vehicles; Battery recycling; Battery swapping; Product-service system; Government subsidy.

## POSTER SESSION 1

# EVALUATING THE SPATIAL LAYOUT OF PUBLIC CHARGING INFRASTRUCTURE FOR E-TAXIS USING GPS TRAJECTORY DATA

A. Meng LIU [a] and B. Sylvia HE [a*]

[a] *Department of Geography and Resource Management,*
*The Chinese University of Hong Kong, China*
**Email: sylviahe@cuhk.edu.hk (Corresponding author)*

Transport electrification is a critical step toward energy conservation and emission reduction. However, the central challenge for electrifying transportation remains insufficient and unsuitable configurations of public charging infrastructure. Therefore, it is necessary to assess the current public charging infrastructure and clarify the layout problems. E-taxi drivers are a particularly time-conscious group and the two most time-consuming activities before charging are seeking a charging station and waiting in queue at charging stations. This study aims to examine e-taxi drivers' seeking time for a charging station and waiting time at charging stations and evaluate the spatial layout of current public charging infrastructure for e-taxis. The time of seeking a charging station and the waiting time at charging stations are extracted from the GPS trajectory data of a fully electrified taxi fleet. The spatial autocorrelation analysis is conducted to explore the spatial patterns of the accessibility and availability of charging stations. The preliminary results indicate that areas with inadequate and unbalanced charging supply for e-taxi drivers exist. Research findings from this study can offer recommendations for the spatial planning of charging infrastructure and better serve e-taxi drivers.

Keywords: electric taxi; public charging infrastructure; seeking time for a charging station; waiting time at charging station

# INCORPORATING MOBILE INTERNET USAGE DATA TO EXPLORE THE IMPACTS OF HUMAN MOBILITY PATTERNS ON SHOPPING MALLS

A. Jiping XING [a], B. Xiaohong JIANG [a*], C. Jianhua DENG [b], D. Churong CHEN [c] and E. Kai ZHANG [d*]

[a] *College of Automobile and Traffic Engineering, Nanjing Forestry University, Nanjing, China*

[b] *School of Civil Engineering, Suzhou University of Science and Technology, China*

[c] *Jiangsu Key Laboratory of Urban ITS, Jiangsu Province Collaborative Innovation Centre of Modern Urban Traffic Technologies, School of Transportation, Southeast University, China*

[d] *Department of Industrial and System Engineering, Faculty of Engineering, The Hong Kong Polytechnic University, Kowloon, Hong Kong, China*

[*] *Email: jiangxh@njfu.edu.cn; zhangk2019@seu.edu.cn (Corresponding author)*

Human mobility patterns on shopping mall, which are characterized by irregular travel behavior, are influenced by the socioeconomic attributes of travelers. However, due to the limitations of acquiring socio-demographic datasets, it is challenging to gain a comprehensive understanding of the heterogeneous factors that influence the trip volumes to shopping malls using a complete sample. To address this gap, we utilize a mobile internet usage dataset, which includes the preferred websites and applications (apps) visited by mobile phone users and time and frequency information. These data serve as portraits of traffic analysis zones (TAZs) that travel to shopping malls. To analyze the impact of trip volumes to shopping malls, we employ partial least squares (PLS) regression models. We test this method in the city of Suzhou, China, using a mobile phone dataset that provides comprehensive spatiotemporal coverage. This dataset includes the positioning data and socioeconomic data estimated based on internet usage preferences of the same users. Our findings reveal that distance, entertainment, dining, and shopping have a significantly higher impact on trip volumes compared to social activities, learning, travel, age, and gender.

Keywords: Human mobility, Shopping malls, Mobile internet usage, Partial least squares, Trip volume impact

# EVALUATING THE SAFETY IMPACT OF REGIONAL COMMUNICATION FAILURES ON CONNECTED AND AUTOMATED VEHICLES

A. Haosong WEN [a, b], B. Weijie YU [a, b] and C. Wei WANG [a, b*]

[a] *Jiangsu Key Laboratory of Urban ITS, School of Transportation, Southeast University, Nanjing, China*

[b] *Jiangsu Province Collaborative Innovation Center of Modern Urban Traffic Technologies, Southeast University, Nanjing, China*

[*] *Email: wangwei_transtar@163.com (Corresponding author)*

Efficient vehicular wireless communication is the key to improving traffic safety for connected and automated vehicles (CAVs). However, wireless communication is vulnerable to equipment failures and communication environment, causing serious damage to traffic safety. So far, transient communication failures of single CAV or CAV platoon and their safety impact have been widely studied, but the persistent communication failures occurring in the fixed area are rarely discussed. To fill in this gap, this study aims to evaluate the safety impact of regional communication failures under pure connected environment. Vehicular driving behaviors are reasonably simulated by comprehensively considering the processes of car-following, lane change, collision warning, and driver's takeover. Then we study three typical communication failures, including random error, random delay, and cyclical missing, and analyze their safety impact in a two-lane freeway scenario with a specific disturbed area. The results indicate that disturbed factors, disturbed severity, and disturbed coverage of various communication failures have diverse safety impacts on CAVs. The findings of this study are potential to provide useful suggestions for defending regional communication failures and improving longitudinal safety of CAVs.

Keywords: Communication failures, Connected and automated vehicles, Safety impact, Lane change, Driver takeover

# OPTIMIZING EMS RESPONSES POST-DISASTER: ROBUST ALLOCATION OF AMBULANCES CONSIDERING TRAVEL TIME UNCERTAINTIES

A. Huiying ZHAO [a], B. Huijun SUN [a*], C. Hao FU [a*] and D. Jianjun WU [a]
[a] *School of Systems Science,*
*Beijing Jiaotong University, Beijing, China*
[*] *Email: hjsun1@bjtu.edu.cn; haof1@bjtu.edu.cn (Corresponding author)*

In the aftermath of a disaster, the efficiency of Emergency Medical Services (EMS) is crucially hindered by uncertain traffic conditions, impacting the timely delivery of medical aid. While existing studies have explored various aspects of disaster response, the specific challenge of scheduling ambulance routes under travel time uncertainties, particularly for prioritized patients, has received limited attention. This paper addresses this gap through robust optimization, accounting for the variability in travel times and the severity of patient injuries. We introduce two integer programming models: a deterministic model focused solely on efficiently dispatching ambulances to pick up prioritized patients and then deliver to appropriate hospitals, and a robust optimization model that incorporates travel time uncertainties to optimize routing under worst-case scenarios. To address the computational challenges inherent in integer programming models for large-scale scenarios, we employ the Branch-and-Benders-Cut algorithm by proposing new valid inequalities to significantly narrow the search region, thereby accelerating the convergence process. Furthermore, the robust optimization model is solved using a robust counterparts approach to transform the uncertain problem into a deterministic problem. These methodological advancements not only improve computational efficiency but also enhance the scalability of the model to more complex scenarios. Both models' performances are compared using two numerical examples, demonstrating that accounting for travel time uncertainty significantly enhances the effectiveness of pre-hospital emergency responses.

Keywords: Emergency events, Emergency Medical Service, Distribution of medical facilities, Robust optimization

# REGULATING DISCRIMINATORY PRICING AGAINST EXISTING CUSTOMERS IN THE TRANSPORTATION MARKET CONSIDERING SUPPLY-DEMAND CONGESTION EFFECTS AND DUOPOLY COMPETITION

A. Jinshu CAI [a], B. Yanyan DING [b] and C. Sisi JIAN [a*]
[a] *Department of Civil and Environmental Engineering,*
*The Hong Kong University of Science and Technology, Hong Kong SAR, China*
[b] *Department of Logistics and Maritime Studies, The Hong Kong Polytechnic University, Hong Kong SAR, China*
[*] *Email: cesjian@ust.hk (Corresponding author)*

The proliferation of price discrimination methods in transportation service markets, facilitated by the platform economy and big data, has raised concerns about equity among the public and regulators. To analyze the impact of price discrimination and discuss regulatory approaches, we develop a two-period pricing competition model that incorporates equity constraints. The model considers the effects of supply-demand congestion and supplier heterogeneity, with two suppliers setting different prices for existing and new customers. Through our modeling framework, we analytically demonstrate that discriminatory pricing arises primarily from the need to account for market coverage limitations associated with uniform pricing, influenced by the outside option and congestion effects. Our findings indicate that implementing price equity constraints can lead to various outcomes, including lose-lose, win-lose, and win-win scenarios, depending on the desired degree of equity and external market factors. In certain conditions, a proper level of equity can incentivize some travelers to shift from the advantaged supplier to the disadvantaged supplier. We conduct a numerical study using car parking data from Hong Kong to validate our theoretical results and analyze changes in consumer surplus and social welfare under different degrees of equity regulations. The numerical results demonstrate that an excessive pursuit of absolute equity can lead to a reduction in social welfare.

Keywords: Price discrimination, Price equity constraints, Congestion effects, Duopoly competition

# INTEGRATING PERSONAL RAPID TRANSIT SYSTEM AT SIGNALIZED INTERSECTIONS: DESIGNING, SIMULATION, AND IMPLICATION

A. Lanhang YE [a*], B. Toshiyuki YAMAMOTO [a*], C. Takayuki ANAMOTO [b], D. Kazuyuki UMIGUCHI [b] and E. Takayuki MORIKAWA [c]

[a] *Institute of Materials and Systems for Sustainability, Nagoya University, Nagoya, Japan*

[b] *Technical Research & Development Center, Yamaha Motor Co., Ltd., Japan*

[c] *Institutes of Innovation for Future Society, Nagoya University, Nagoya, Japan*

[*] *Email: ye.lanhang.n2@f.mail.nagoya-u.ac.jp; yamamoto@civil.nagoya-u.ac.jp (Corresponding authors)*

Incorporating emerging mobility services into established transport systems has consistently presented inherent challenges. A primary difficulty lies in effectively managing the re-allocation of time and space resources, particularly at signalized intersections, which serve as pivotal nodes within urban networks. This research aims to introduce an innovative Personal Rapid Transit (PRT) system integrated with autonomous vehicles, operating on both dedicated lanes and local streets, to achieve plausible levels of mobility and accessibility simultaneously. To assess the feasibility of this integration, simulation scenarios were developed using VISSIM to evaluate and identify potential locations for dedicated PRT lanes at signalized intersections. These configurations include placement in the middle of the roadway, by the roadside, and in one-way settings. Two signalized intersections in Kasugai, Japan, serve as case studies: Ishiodai IC, characterized by a triangular shape, and a cross intersection at Ishiodai Minami. Signal timing plans incorporating protected PRT phases were evaluated. The efficacy of various plans was assessed through simulation experiments, and the resilience of the integrated system was examined through simulations of emergency scenarios involving the suspension of signal control and the activation of all-red signals. This study serves as a reference model for introducing emerging mobility services and facilitating their integration with existing urban transport systems.

Keywords: Personal rapid transit, Urban mobility, Signalized intersection, Traffic simulation

# COST-COMPETITIVENESS ANALYSIS OF MOBILE CHARGERS IN AN ELECTRIC VEHICLE PARKING AND CHARGING SYSTEM

A. Yanling DENG [a,b,c], B. Zhibin CHEN [a,b*] and C. Xi LIN [d]
[a] *Shanghai Frontiers Science Center of Artificial Intelligence and Deep Learning, NYU Shanghai, Shanghai, China*
[b] *Shanghai Key Laboratory of Urban Design and Urban Science, NYU Shanghai, Shanghai, China*
[c] *Department of Civil and Urban Engineering, New York University, NY, United States*
[d] *Department of Civil and Environmental Engineering, University of Michigan, MI, United States*
**Email: zc23@nyu.edu (Corresponding author)*

Currently, mobile chargers (MCs) are gaining popularity owing to their flexibility and the potential to solve the widespread issue of chargers being occupied after the charging process has finished, due to delayed departures of electric vehicles (EVs). In this study, we investigate the adoption of MCs in the EV parking and charging system (EVPCS) and demonstrate its cost-competitiveness through comparison with fixed chargers (FCs). First, we propose a modified M/M/n/K queueing model with two-phase services to capture the EVs' dwell-after-charging behavior. Then we present the steady-state analysis with a matrix analytical method to analyze the properties of the proposed models. To evaluate and compare the performances of these two types of charging facilities, several key measures like blocking probability, average queue length and delay, and chargers' utilization rate are derived, and extensive experiments exploring diverse scenarios are obtained. Numerical results uncover that: (1) the EVPCS configuration and EVs' arrival and service rates have distinct impacts on the performance metrics of different types of chargers; (2) the MC may lose its competitiveness if the EV arrival rate is relatively low along with a high charging service rate or when the charger proportion approaches 1 in a small-sized EVPCS; only when the system is overloaded would the MC have a higher level of service than the FC; (3) in terms of cost efficiency, MCs demonstrate better competitiveness than the low-powered FCs considering the equivalent service with higher consumer surplus, while competing with moderately to high-powered FCs, MCs have little superiority; MCs are more profitable to the operator when competing with either low or high-powered FCs, but not for moderately-powered FCs; yet, the MC's charging powers is required to be at an acceptably moderate level to demonstrate its cost-competitiveness. Furthermore, analytical formulas have been developed to approximate the two-phase queueing model under certain scenarios, and their accuracy has been compared with the customized two-phase queuing model.

Keywords: Mobile charger; Electric vehicle parking and charging system; Queueing model; Cost competitiveness

# EVALUATING TRAFFIC PERFORMANCE OF DEDICATED LANES FOR CONNECTED AND AUTOMATED VEHICLES AT URBAN ROUNDABOUTS

A. Xu ZHANG [a*] and B. Zhiman XU [a]
[a] *Department of Transportation Engineering, Chang'an University, Xi'an, China*
[*] *Email: xuzhang@chd.edu.cn (Corresponding author)*

The integration of Connected and Automated Vehicles (CAVs) within urban traffic systems presents a transformative approach to addressing contemporary traffic challenges. This study explores the effectiveness of implementing dedicated CAV lanes at urban roundabouts, focusing on the impact on traffic performance metrics such as travel speed and average delay. Employing microsimulation techniques, this paper assesses the implications of various CAV lane configurations and market penetration rates at the Bell Tower Roundabout in Xi'an, China. The simulations reveal that dedicated CAV lanes significantly enhance traffic efficiency, particularly as the market penetration of CAVs increases. However, at lower penetration rates, the presence of CAVs poses some concerns. The findings indicate that with strategic deployment of dedicated lanes, both travel time reduction and traffic flow enhancement are achievable. Additionally, this study conducts a sensitivity analysis considering factors like varying traffic demands to further understand the dynamics under different traffic scenarios. Our results demonstrate that dedicated CAV lanes not only improve traffic efficiency but also mitigate potential safety risks, validating the necessity of such lanes particularly in high traffic conditions. This research provides actionable insights for urban planners and traffic managers, supporting the broader integration of CAV technologies into complex urban environments.

Keywords: Dedicated lane, Connected and automated vehicle, Microsimulation, Traffic performance, Roundabout

# LEVERAGE MULTI-SOURCE TRAFFIC DEMAND DATA FUSION WITH TRANSFORMER MODEL FOR URBAN PARKING PREDICTION

A. Yin HUANG [a], B. Yongqi DONG [b*], C. Youhua TANG [a*] and D. Li LI [c]
[a] *School of Transportation and Logistics, Southwest Jiaotong University, China*
[b] *Institute of Highway Engineering, RWTH Aachen University, Aachen, Germany*
[c] *Department of Automation, BNRist, Tsinghua University, China*
[*] *Email: y.dong-4@tudelft.nl; tyhctt@swjtu.cn (Corresponding author)*

The escalation in urban private car ownership has worsened the urban parking predicament, necessitating effective parking availability prediction for urban planning and management. However, the existing prediction methods suffer from low prediction accuracy with the lack of spatial-temporal correlation features related to parking volume, and neglect of flow patterns and correlations between similar parking lots within certain areas. To address these challenges, this study proposes a parking availability prediction framework integrating spatial-temporal deep learning with multi-source data fusion, encompassing traffic demand data from multiple sources (e.g., metro, bus, taxi services), and parking lot data. The framework is based on the Transformer as the spatial-temporal deep learning model and leverages K-means clustering to establish parking cluster zones, extracting and integrating traffic demand characteristics from various transportation modes (i.e., metro, bus, online ride-hailing, and taxi) connected to parking lots. Real-world empirical data was used to verify the effectiveness of the proposed method compared with different machine learning, deep learning, and traditional statistical models for predicting parking availability. Experimental results reveal that, with the proposed pipeline, the developed Transformer model outperforms other models in terms of various metrics, e.g., Mean Squared Error (MSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE). By fusing multi-source demanding data with spatial-temporal deep learning techniques, this approach offers the potential to develop parking availability prediction systems that furnish more accurate and timely information to both drivers and urban planners, thereby fostering more efficient and sustainable urban mobility.

Keywords: Parking availability prediction, Spatial-temporal correlation, Deep learning, Clustering, Multi-source data fusion, Urban mobility

# CO-DESIGN OF TRADITIONAL AND DEMAND-RESPONSIVE TRANSIT BASED ON EXISTING STOPS

A. Zili TIAN [a], B. Jiaorong WU [a*], C. Sicheng WANG [a] and D. Chi ZHAO [a]

[a] *Key Laboratory of Road and Traffic Engineering of the Ministry of Education, Tongji University, Shanghai, China*

[*] *Email: wjrshtj@163.com (Corresponding author)*

To address the inefficiency of traditional bus transit in low-population-density areas, considering introducing irregular route demand-responsive transit (DRT) based on existing bus stops, a transit mode design method based on a combination of traditional and demand-responsive transit systems was proposed. A nonlinear programming model, with minimum time cost as the optimization objective, was developed and solved using a genetic algorithm. The results of the sensitivity analysis indicated that the more approachable the demand-responsive stops are and the more concentrated the user travel direction is, the more appropriate it is to apply DRT to enhance the bus system. Huating Town, Shanghai was selected as a typical low-population-density area for an example design. The results showed that passenger travelling efficiency and enterprise operating efficiency are improved by 22.2% and 15.1%, respectively. Moreover, the implementation performance was better than in neighbouring urban areas with higher population density. Through contextualised considerations and data-driven simulations, this study validates the effectiveness and feasibility of co-design of traditional bus and DRT.

Keywords: co-design, demand-responsive transit, nonlinear programming, genetic algorithm, real scenerio

# UNLOCKING THE POTENTIAL OF DRONES IN REVOLUTIONIZING INTRA-CITY EXPRESS SERVICES: A COST-EFFICIENCY ANALYSIS

A. Lingxiao WU [a*], B. Xiao CHU [a], C. Shuiwang CHEN [a], D. Kai WANG [b] and E. Gangyan XU [a]

[a] *Department of Aeronautical and Aviation Engineering,*
*The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, 999077, China*

[b] *School of Vehicle and Mobility, Tsinghua University, Beijing, 100084, China*

[*] *Email: lingxwu@polyu.edu.hk (Corresponding author)*

Drones have emerged as promising transportation tools in the urban logistics industry, particularly for short-distance transportation, such as last-mile delivery and food delivery. With advancements in coverage range and payload capacity, medium drones are poised to open up a medium-range urban logistics market known as intra-city express service (ICES). This study aims to examine the benefits of deploying drones into ICES by comparing the costs and efficiency of current truck-based ICES with four potential drone-based modes: station-to-station (S-S), vertiport-to-vertiport (V-V), station-to-hub-to-station (S-H-S, with hub denoting distribution center), and vertiport-to-hub-to-vertiport (V-H-V). Based on the dataset from a courier in China, a thorough examination of the cost- and time-saving advantages associated with drone-based modes is conducted. The results demonstrate the promising potential of deploying drones in the ICES industry to save costs and enhance efficiency, but these benefits are highly dependent on the operational mode of drones. Among the proposed modes, none emerges as a dominant option across both metrics. Nevertheless, the V-V and V-H-V stand out as non-dominant modes, with V-V offering the highest time efficiency and V-H-V proving to be the most cost-efficient. Vertiports and distribution centers are crucial facilities for achieving cost reduction as they facilitate parcel consolidation. However, distribution centers may not necessarily enhance efficiency since they can introduce additional waiting time and detours. Overall, the managerial insights and policy implications proposed in this study demonstrate significant potential for the utilization of drones in intra-city express service.

Keywords: intra-city courier service, drone logistics, operational costs, delivery time, cost-efficiency analysis

# AN ANALYSIS OF TOURISTS' WILLINGNESS-TO-PAY FOR BUNDLED ONE-DAY TRANSPORT TICKET IN THE CENTRAL NAGOYA WITH THE PRICE SENSITIVITY MEASUREMENT

A. G. HAYAUCHI [a*], B. R. KANAMORI [a] and C. T. MORIKAWA [a]
[a] *Institutes of Innovation for Future Society, Nagoya University, Nagoya, Japan*
[*] *Email: mail@genhayauchi.jp (Corresponding author)*

Efforts to create seamless mobility environments by integrating various transport services have been accelerated under the current trend focusing on Mobility as a Service (MaaS). Discussions on bundled, integrated ticketing systems are studied or practiced globally, while there is still room for case studies. This study reveals tourists' willingness to pay for integrated tickets offering multiple transportation services in central Nagoya, Japan. A survey was conducted from September to October 2023 among tourists using a sightseeing bus in the city center. The sample size was 218. Respondents evaluated four ticket options, each bundling different mobility services including the sightseeing bus, subways, cycle-sharing, and demand-responsive transport. Price Sensitivity Measurement (PSM) analysis identified that the ideal price for respondents was 894 JPY for the existing one-day ticket for the sightseeing bus and subways. This ticket is currently priced at 870 JPY on weekdays and 620 JPY on weekends, aligning with the ideal price on weekdays but significantly lower on weekends. Further analysis on hypothetical tickets combining other transport modes like cycle-sharing or demand-responsive transport revealed potential willingness to pay increments compared to existing ticket prices. For instance, adding cycle-sharing to the sightseeing bus ticket increased the ideal price to 786 JPY, highlighting additional payment willingness of around 300 JPY. In summary, this study elucidates users' willingness to pay for subscription passes integrating multiple transport modes. It provides insights into comparing current ticket prices, gauging payment willingness for existing services not yet bundled, and estimating hypothetical payment thresholds for new integrated services.

Keywords: Willingness-to-pay, price sensitivity measurement, Mobility as a service, Public transport

# ENHANCING ON-RAMP AREA CONTROL IN HETEROGENEOUS TRAFFIC FLOW: A DUALMODULE COOPERATIVE APPROACH FOR CONNECTED AND AUTOMATED VEHICLES LEVERAGING REINFORCEMENT LEARNING

A. W. YANG [a], B. C. DONG [a], C. Z. ZHANG [a], D. X. CHEN [a] and E. H. WANG [a]*
[a] *School of Transportation, Southeast University, Nanjing, 211189, China*
**Email: haowang@seu.edu.cn (corresponding author)*

The interaction among vehicles in on-ramp merging areas presents significant challenges for both traffic efficiency and safety. The emergence of connected and automated vehicles (CAVs) holds promise as a solution to these challenges. This study introduces an innovative dual-module cooperative control strategy specifically designed for on-ramp areas where CAVs and human-driven vehicles (HDVs) share the road. Utilizing reinforcement learning techniques, the proposed approach consists of two primary components: a merging control module and a lane-changing control module. The merging control module facilitates smooth interactions between mainline vehicles and ramp vehicles, while the lane-changing control module assists mainline CAVs in making informed decisions about changing lanes. Through the implementation of the proximal policy optimization reinforcement learning algorithm, the agents within these modules are trained to optimize their performance. Simulation results demonstrate significant enhancements in traffic efficiency and safety achieved by this dual-module control strategy in on-ramp areas, particularly in CAV-HDV heterogeneous traffic flow scenarios. Even with a relatively low penetration rate of CAVs (0.2), there is a notable 26% reduction in average vehicle delay, highlighting the effectiveness of the approach. Furthermore, regarding safety, a CAV penetration rate of 0.3 or higher results in an approximately 45% reduction in time exposed time-to-collision. The findings of this study will contribute to the development of more efficient and safer intelligent transportation systems.

Keywords: Connected and automated vehicle; on-ramp; heterogeneous traffic flow; reinforcement learning.

# OPTIMIZING VEHICLE RESPONSES IN ACCIDENT SCENARIOS: A REINFORCEMENT LEARNING APPROACH WITH V2X COMMUNICATION

A. Hyun Seop SIM [a] and B. Shin Hyoung PARK [a*]
[a] *Department of Transportation Engineering, The University of Seoul, Republic of Korea*
* *Email: shinhpark@uos.ac.kr (Corresponding author)*

In this study, we introduced a comprehensive approach that uses simulation and deep reinforcement learning to improve road safety and efficiency in accident situations. Frist, we used the VISSIM simulation tool to create traffic scenarios where vehicles simulate impending accidents and attempt to change lanes. In these scenarios, autonomous vehicles collect information through Vehicle-to-Everything(V2X) communication and detects the accident situation before proactively attempting to change lanes. This setting allows the dynamic implementation of accident scenarios to evaluate the responsiveness of autonomous vehicles under various conditions. And then, we trained the autonomous vehicles using the Deep Deterministic Policy Gradient (DDPG) algorithm. This framework allows the vehicles to continuously adapt to data and learn to develop safe, comfortable, and efficient driving behaviors. These lane-change behaviors are rewarded based on safety, comfort, and efficiency. The DDPG algorithm optimizes behaviors such as speed control and lane-changing to minimize the risk of accidents while maintaining traffic flow. This study shows that vehicles equipped with V2X communication and reinforcement learning algorithms improve the safety, efficiency, and comfort of autonomous vehicles in lane-changing situations. This result improves overall traffic safety and congestion, potentially leading to the development of more intelligent and safer autonomous driving systems.

Keywords: Accident, V2X, Lane changes, Micro traffic simulation, Deep reinforcement learning, DDPG algorism

# AN END-TO-END SMART PREDICT-THEN-OPTIMIZE FRAMEWORK FOR VEHICLE RELOCATION IN LARGE-SCALE CROWD SENSING

A. XINYU WANG [a] and B. WEI MA [a*]
[a] *Department of Civil and Environmental Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
**Email: wei.w.ma@polyu.edu.hk (Corresponding author)*

The ubiquitous mobile devices have catalyzed the development of mobile sensing. The vehicle sensing systems show great potential in the flexible acquisition of extensive spatio-temporal data through built-in smart sensors under diverse sensing scenarios. However, vehicle systems like taxis often exhibit inherent biases due to the heterogeneous nature of trip requests and varied driving paths. To achieve a high sensing coverage, a critical challenge lies in how to optimally relocate vehicles to minimize the divergence between their spatio-temporal distributions and target sensing distributions. Conventional approaches typically employ a two-stage predict-then-optimize (PTO) process: first predicting real-time vehicle distributions and subsequently generating an optimal relocation strategy based on the predictions. However, this method can lead to suboptimal decision-making due to the propagation of errors from upstream prediction. To this end, we develop an end-to-end Smart Predict-then-Optimize (SPO) framework by integrating optimization into prediction within the deep learning architecture, and train the entire framework by minimizing the task-specific matching divergence rather than the upstream prediction errors. Additionally, we formulate the vehicle relocation problem by quadratic programming (QP) and incorporate a novel alternating differentiation technique within the SPO framework to compute gradients of the QP layer, facilitating backpropagation. We evaluate the proposed SPO framework on real-world mid-size and large-scale networks with various target distributions, utilizing a real-time taxi dataset from Hong Kong. The results demonstrate that the proposed SPO framework, coupled with the alternating differentiation technique, outperforms conventional methods in both effectiveness and robustness, proving feasible for large-scale network applications.

Keywords: Vehicle relocation, Crowd sensing, Large-scale, Smart Predict-then-Optimize, Alternating differentiation method

# EFFICIENT MODEL COMPRESSION FOR IMPROVING TRAFFIC OBJECT RECOGNITION USING LIGHTWEIGHT PRUNING ALGORITHM

A. Huihuang ZHU [a*], B. Ruyi FENG [a] and C. Zhibin LI [a*]
[a] School of Transportation, Southeast University, China
*Email: huihuang.zhu@seu.edu.cn; lizhibin@seu.edu.cn (Corresponding authors)*

The development of intelligent transportation systems requires extensive deployment of roadside units, yet the complexity of state-of-the-art visual AI models challenges real-time implementation on resource-limited devices. To address this, we propose a convolutional network compression algorithm that is versatile across models and offers controllable compression rates, significantly reducing model parameters while preserving accuracy. The algorithm enhances network efficiency by determining pruning rates for each convolutional layer and selecting filters based on a novel metric that quantifies information richness using matrix rank. Recognizing that feature extraction in each layer relies on the collective contribution of its filters, filters are categorized for optimal selection. Experiments on CIFAR-10, KITTI, and VOC-2classes datasets validate the method's effectiveness, showing significant reductions in computational complexity and model size with minimal accuracy loss. On KITTI and VOC-2classes, the algorithm reduced YOLOv5's model size by over 40% with only a slight decrease in mAP@0.5, demonstrating its suitability for traffic object recognition on edge devices in intelligent transportation systems.

Keywords: Neural Network Compression, Filter Pruning, Image Classification, Object Detection, Efficient Inference

## POSTER SESSION 2

# ENHANCED OBJECT DETECTION ALGORITHM WITH PREDICTION BOX EXTENSION

A. S WANG [a], B. G YU [a], C. Z WANG [a], D. S GAO [b] and E. P WANG [b*]
[a] *School of Transportation Science and Engineering, Beihang University*
[b] *School of Cyber Science and Technology, Beihang University, Beijing, China*
[*] *Email: pcwang@buaa.edu.cn (Corresponding author)*

Due to the insufficient interpretability of neural networks, the perceptual results may not always meet the requirements in the context of autonomous driving applications,leading to unguaranteed Safety Of The Intended Functionality (SOTIF) issues. To address the inadequacies in safety during the current object detection process, our research enhances the classical one-stage object detection algorithm YOLOv5 and introduces an algorithm for extending prediction box in image object detection. This algorithm takes into account the coverage range and redundancy of real targets, ensuring the safety of image perception. For safety issues in the process of object detection by lidar point cloud, this paper proposes a point cloud object detection prediction box extension algorithm, which is integrated with PointPillars to increase the coverage range of real targets and ensure the algorithm's safety during the point cloud object detection process. The results of merging image object detection and lidar point cloud object detection show that the proposed object detection fusion algorithm increases the coverage range of detected targets by 5.3%, significantly enhancing perception safety in the autonomous driving process.

Keywords: Object Detection, Prediction Box Extension, Autonomous Vehicles, multiple sensor fusion

# MODULAR AUTONOMOUS VEHICLE IN HETEROGENEOUS TRAFFIC FLOW: MODELING, SIMULATION, AND IMPLICATION

A. Lanhang YE [a*] and B. Toshiyuki YAMAMOTO [a*]

[a] *Institute of Materials and Systems for Sustainability, Nagoya University, Nagoya University, Nagoya, Japan*

[*] *Email: ye.lanhang.n2@f.mail.nagoya-u.ac.jp; yamamoto@civil.nagoya-u.ac.jp (Corresponding authors)*

Modular autonomous vehicles (MAVs) represent a groundbreaking concept that integrates modularity into the ongoing development of autonomous vehicles. This innovative design introduces unique features to traffic flow, allowing multiple modules to seamlessly join together and operate collectively. To understand the traffic flow characteristics involving these vehicles and their collective operations, this study established a modeling framework specifically designed to simulate their behavior within traffic flow. The mixed traffic flow, incorporating arbitrarily formed trains of various modular sizes, is modeled and studied. Simulations are conducted under varying levels of traffic demand and penetration rates to examine the traffic flow dynamics in the presence of these vehicles and their operations. The simulation results and macroscopic fundamental diagrams of the mixed traffic flow are analyzed. The simulation findings indicate that integrating MAVs and their collective operations can substantially enhance capacity, with the extent of improvement depending on the penetration rate in mixed traffic flow. Notably, the capacity nearly doubles when the penetration rate exceeds 75%. Furthermore, their presence significantly influences and regulates the free-flow speed of the mixed traffic. Particularly, when variations in operational speed limits exist between the MAVs and the background traffic, the mixed traffic adjusts to the operating velocity of these vehicles. This study provides insights into potential future traffic flow systems incorporating emerging MAV technologies.

Keywords: Modular Autonomous Vehicle, Traffic flow modeling, Traffic simulation, Fundamental diagram

# RESOURCE ALLOCATION FOR DYNAMIC PLATOON DIGITAL TWIN NETWORKS: A MULTI-AGENT DEEP REINFORCEMENT LEARNING METHOD

A. Lei WANG [a*] and B. Hongbin LIANG [a]

[a] *School of Transportation and Logistics, The Southwest Jiaotong University, ChengDu, China*

**Email: a.corr.wanglei@my.swjtu.edu.cn (Corresponding author)*

Vehicle driving in a platoon is an efficient and ecological driving solution. Introducing the concept of digital twin (DT) into the platoon to establish platoon digital twin (PDT) can improve the management efficiency and driving safety of the platoon. However, the joint allocation of multiple types of resources in a platoon digital twin network (PDTN) is an important issue for the successful implementation and maintenance of the PDT. In this paper, we investigate the resource allocation problem in a PDTN. By comprehensively considering the effects of high mobility of platooning vehicles, real-time nature of the DTs, and multi-vehicle cooperation, we propose a PDT utility optimization model for bandwidth and computation resource allocation. We formulate the dynamic resource allocation problem as an M-th order Markov decision process (MDP) and design a deep reinforcement learning (DRL)-based dynamic resource allocation (DRLDRA) method to solve it. To optimize the actions of the agent, we reshape the state in a smaller time granularity to better reflect the temporal variations of the state. Correspondingly, we design temporal feature extraction neural networks (TFENNs) based on multihead self-attention (MHSA) mechanism and long short-term memory (LSTM) to extract the temporal features of the state. To improve the learning efficiency, a decentralized multi-agent deep deterministic policy gradient (DDPG)-based learning framework is proposed. Numerical results show that the DRLDRA method performs excellently and outperforms other benchmark methods.

Keywords: Digital twin, platoon, resource allocation, deep reinforcement learning

As at December 7, 2024

# UNDERSTANDING THE PSYCHOLOGICAL FACTORS AFFECTING NON-USERS' ADOPTION OF PUBLIC TRANSPORTATION: CASE STUDY OF SURAT, INDIA

A. R. PRAJAPATI [a*], B. R. RATHOD [b*], C. J. PARMAR [c*], D. G. JOSHI [b*] and E. S. DAVE [a*]

[a] *Department of Civil Engineering, Faculty of Technology and Engineering, The Maharaja Sayajirao University of Baroda, Vadodara 390001, India*

[b] *Department of Civil Engineering, Sardar Vallabhbhai National Institute of Technology (SVNIT), Ichhanath, Surat, India-395007*

[c] *Faculty of Engineering, University of Niccolò Cusano, Via Don Carlo Gnoochi, 7, 00166, Rome, Italy*

[*] *Email: rajprajapati1142@gmail.com; rohit.rathod2230@gmail.com; janak.parmar@unicusano.it; gj@ced.svnit.ac.in; smdave-ced@msubaroda.ac.in (Corresponding author)*

In developing countries like India, significant challenges are associated with the use of Public Transport (PT), particularly among choice riders whose psychology plays a crucial role in their decision to opt for public transportation. Traditionally, choice models have mostly focussed on quantifiable variables such travel cost; time; distance, and socio-economic characteristics of riders. However, less attention has been made towards psychological variables such as attitude of riders, and travellers' perception. Present study investigates the psychological variables affecting private transportation users' intentions to use public transportation. To predict and explain human behavior, Theory of Planned Behavior (TPB) has widely used. TPB considers attitude, subjective norms, perceived behavioral control, and behaviour intention. Face-to-face questionnaire survey was conducted among 473 respondents randomly chosen in the fast-growing metropolitan city of Surat, India. Exploratory factor analysis (EFA), followed by confirmatory factor analysis (CFA) have been used to examine the relationship between psychological factors and the intention to use public transportation. The findings show that perceived behavioral control (as latent construct) has more positive relationship with intention to use public transport, followed by attitude and subjective norms. Among attitude measurement waiting time span and its variation affects greatly, while encouragement through surrounding people (colleagues, family member, and neighbour) defines the subjective norms towards the intention to use PT. In perceived behavioural control, easy of travel by PT and it's travel time reliability shows significant impact on the overall behaviour intention, and future policy implication towards the non-users' mode shift should be based on these observed behaviour.

Keywords: Non-users, Theory of Planned Behavior, Psychological factors, Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA)

# THE EFFECT OF AIR QUALITY ON THE DISTRIBUTION OF TOURISTS BASED ON MOBILE PHONE DATA

A. Hongjian BAI [a*], B. Xiao HUANG [a*], C. Kunbo SHI [a*] and D. Yacan WANG [a*]

[a] *Beijing Jiaotong University, China*

[*] *Email: 20271175@bjtu.edu.cn; 21120513@bjtu.edu.cn; kbshi@bjtu.edu.cn; ycwang@bjtu.edu.cn; (Corresponding authors)*

As a serious environmental problem at present, air pollution has seriously affected tourists' behavior, thus causing losses to the tourism industry. Using mobile phone triangulation data of Nanjing in October 17-23, 2016, and developing fixed effect panel regression models, this study examines the impact of air pollution – proxied by PM2.5 – on the distributions of tourists within scenic zones. The results found that for every 10% increase in PM2.5 content, the number of tourists within a 100-meter radius of each scenic zone decreased sig-nificantly by 1.75%, equivalent to a decrease of nearly 12,600 visitors per month, and the number of tourists within a 200-meter radius of each scenic zone decreased significantly by 2.13%, equivalent to a decrease of more than 28,100 visitors per month. The public has a higher travel intention on weekends, which moderates the negative impact of PM2.5 on the distribution of tourists. The availability of public transit infrastructure represented by bus stops enhances the crowding-out effect of PM2.5 on the distributions of tourists. The find-ings of this study highlight the importance of reducing air pollution, and provide policy recommendations for mitigating the loss of tourists caused by air pollution.

Keywords: Air pollution, Tourists, PM2.5, Mobile triangulation data, Analysis of heterogeneity, Nanjing (China)

# HOW DO THE DRIVERS REACT TO DIFFERENT C-V2X ENVIRONMENTS IN DILEMMA ZONES? A DRIVING SIMULATOR STUDY

A. Shi YE [a], B. Tiantian CHEN [a*], C. Oscar OVIEDO-TRESPALACIOS [b], D. Taeho OH [a] and E. Inhi KIM [a]

[a] *Cho Chun Shik Graduate School of Mobility,*
*Advanced Institute of Science and Technology, Daejeon City, South Korea*

[b] *Faculty of Technology, Policy and Management, Delft University of Technology, Delft, The Netherlands*

[*] *Email: nicole.chen@kaist.ac.kr (Corresponding author)*

In South Korea, accidents at signals-controlled intersections are rising. Our attention is drawn to the safety behavior of drivers at intersections, since many may slip into dilemma mode during yellow traffic lights. In such conditions, connected vehicle technology makes safety guidance possible. In recent studies, communication loss or delay has been tested for its effect on safety. The experimental settings, however, are not compatible with the up-to-date CV2-X technology. There has been little research on how drivers interact with the future possible communication scenarios and during critical events. In order to achieve a more realistic experimental setting, a digital-twin platform combining Unity and VISSIM was developed. Driving simulator experiments were conducted with 80 drivers. There are five different communication conditions including (1) no communication, (2) perfect communication with a countdown guidance, (3) perfect communication with stop/go guidance, (4) communication interruption due to network connectivity, and (5) communication loss due to absence of smart infrastructure. 6 yellow lights were set up at varying time points from the stop-line in one trial to capture the driver's dilemma zone experience approaching an intersection. Driving performance indicators includes speed and lateral controls. The repeated measures ANOVA will be used to compare driving performance in different communication environments. To assess the associations between performance indicators and factors such as communication environments, time to stop-line, and individual characteristics, a group random parameters regression model will be used. The findings will ensure the evolution of CV2X technology can meet future demand as well as improve driving safety.

Keywords: Co-simulation, Driving simulator, Connected vehicle, Communication environment, Dilemma zone, Driving performance

As at December 7, 2024

# BATTERY SWAPPING STATION LOCATION AND CHARGING SCHEDULING FOR THE E-BIKE SHARING SYSTEM UNDER STOCHASTIC DEMAND

A. Yisong CHEN [a], B. Zhimian WANG [a], C. Kun AN [a*] and D. Hai JIANG [b]

[a] *The Key Laboratory of Road and Traffic Engineering of the Ministry of Education, Tongji University, 4800 Cao'an Road, Shanghai 201804, China*

[b] *Tsinghua University, China*

[*] *Email: kunan@tongji.edu.cn (Corresponding author)*

E-bike sharing systems (EBSS) is an emerging transport mode in recent years, which gained great popularity in small cities and towns with limited public transport services. Most EBSS adopt the battery swapping mode in order to improve their bike utilization rates. The system operator dispatches a team of staff to pick up fully charged batteries and drive to the EBSS stations with depleted batteries to perform the battery swapping. In addition, an imbalance between supply and demand at stations occurs due to the underlying directional demand during EBSS operations. EBSS tend to concentrate at low pick-up demand stations and have shortage problems at high pick-up demand stations. Operators also have to perform e-bike rebalancing from stations to stations to achieve e-bike demand-supply balance. The operation efficiency of the EBSS is thus closely related to the deployment location and density of its battery swapping stations. This paper investigated the battery swapping station location and operation vehicle routing to realize e-bike rebalancing and battery swap duties under demand uncertainty. The problem is formulated as a two-phase stochastic program in which the station location and daily operation are separated.We propose a customized genetic algorithm to solve the model, which delivers feasible solutions significantly faster than the Gurobi solver, reducing the solution time by up to 55.3% in small-scale problems. The algorithm maintains strong performance in large-scale problems, while the solver is no longer able to generate a feasible solution within the specified time.

Keywords: Shared E-bike, Station location, Battery swapping, Rebalancing, Two-stage stochastic program

As at December 7, 2024

# REVEALING CHARGING PATTERNS OF ELECTRIC VEHICLES WITH INTRINSIC USAGE HETEROGENEITY

A. Ruinan WANG [a,b], B. Zhibin CHEN [a,b] and C. Zhengtian XU [c*]
[a] *School of Ecological and Environmental Sciences, East China Normal University, Shanghai, China*
[b] *Shanghai Frontiers Science Center of Artificial Intelligence and Deep Learning, NYU Shanghai, Shanghai, China*
[c] *Department of Civil and Environmental Engineering, George Washington University, Washington, DC*
**Email: zhengtian@gwu.edu (Corresponding author)*

With the increasing adoption of electric vehicles (EVs), location-based data have become common resources for understanding EV usage and charging patterns. Compared to survey data, these data sources provide more comprehensive historical records and offer more reliable insights into user preferences. However, due to the nature of data collection and privacy protection measures, pinpointing the data origin to highly specific groups is challenging. As a result, location-based data, often sampled from a general population, exhibit intrinsic and hidden heterogeneity among individuals, which can make aggregate behavioral analyses less effective. To better support facility planning and enhance user experiences, effective approaches are needed to cluster individuals based on their EV usage characteristics and differentiate between heterogeneous user groups. To address this gap, our study proposes a three-stage method for identifying trip purposes and classifying EVs based on their usage types, considering both vehicle- and trip-level attributes. Using real-world driving and charging data from a sample of EVs in Shanghai, we categorize these vehicles into five usage types: two types of private vehicles and three types of commercial vehicles. We then examine variations in charging demand and preferences across these categories. This high-granularity classification and analysis not only aid in optimizing the configuration of charging infrastructure but also provide more precise data to support power system management and policy development.

Keywords: Electric vehicle; Charging behavior; Driving pattern; Trip purpose inference; Vehicle classification; Empirical analysis

# GENERALIZABLE IMPLICIT NEURAL REPRESENTATION AS A UNIVERSAL SPATIOTEMPORAL TRAFFIC DATA LEARNER

A. Tong NIE [a], B. Guoyang QIN [b], C. Wei MA [a*] and D. Jian SUN [b]

[a] *Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hong Kong SAR, China*

[b] *Department of Traffic Engineering, Tongji University, Shanghai, China*

**Email: wei.w.ma@polyu.edu.hk*

Spatiotemporal Traffic Data (STTD) measures the complex dynamical behaviors of the multiscale transportation system. Existing methods aim to reconstruct STTD using low-dimensional models. However, they are limited to data-specific dimensions or source-dependent patterns, restricting them from unifying representations. Here, we present a novel paradigm to address the STTD learning problem by parameterizing STTD as an implicit neural representation. To discern the underlying dynamics in low-dimensional regimes, coordinate-based neural networks that can encode high-frequency structures are employed to directly map coordinates to traffic variables. To unravel the entangled spatial-temporal interactions, the variability is decomposed into separate processes. We further enable modeling in irregular spaces such as sensor graphs using spectral embedding. We validate its effectiveness through extensive experiments in real-world scenarios, showcasing applications from corridor to network scales. Results not only indicate that our model has significant superiority over conventional low-rank models, but also highlight that the versatility of the approach extends to different data domains, output resolutions, and network topologies.

Keywords: Implicit neural representations, Traffic data learning, Spatiotemporal traffic data, Traffic dynamics, Multilayer perceptron

## POSTER SESSION 3

# RIDESHARING USER EQUILIBRIUM MODEL AND ITS EQUIVALENT VARIATIONAL INEQUALITY FORMULATION WITHOUT MONOTONICITY: A DECOMPOSITION-BASED APPROXIMATION APPROACH

A. Wenxin ZHOU [a], B. Xiaolei WANG [a*], C. Jie YANG [a] and D. Xiaoning ZHANG [a]
[a] *School of Economics and Management*
*Tongji University, Shanghai, China*
[*] *Email: xiaoleiwang@tongji.edu.cn (Corresponding author)*

The traffic assignment problem in the presence of ridesharing service based on user equilibrium principle, known as ridesharing user equilibrium (RUE) model, has drawn increasing attention in recent years. However, due to the intrinsic complexities, existing models are either based on various unrealistic assumptions (i.e., restricting the driver and the rider in each ridesharing pair to be within the same origin-destination (OD) pair, forcing en-route vehicle transfer, and/or assuming the driver/rider role of each user is fixed) or require path enumeration to solve. In this paper, for this RUE problem, we relax these unrealistic assumptions, and formulate it into an equivalent variational inequality (VI) problem. As this VI problem is generally non-monotone, we decompose it into a subproblem, which is equivalent to a Beckmann formulation with side constraints, and a non-monotone master problem. Thedualsubgradient algorithm with averaging combined together with the self-adaptive column generation techniques is applied to effectively solve the subproblem. And for the non-monotone master problem, we approximate it by a convex quadratic programming (QP) problem through the application of the constant approximation scheme, and solved by the off-the-shelf solver. The convergence of the proposed algorithm is rigorously proved and the efficiency of the algorithm is demonstrated through numerical experiments.

Keywords: Ridesharing user equilibrium, non-monotone variational inequality, decomposition-based approximation approach

# MODELING THE UNCERTAINTIES FROM DATA IMPERFECTION AND TASTE HETEROGENEITY IN LINK-BASED ROUTE CHOICE ANALYSIS VIA BAYESIAN VARIATIONAL INVERSE REINFORCEMENT LEARNING (BVIRL)

A. Junze YANG [a] and B. Xiangdong XU [a*]
[a] *The Key Laboratory of Road and Traffic Engineering, Ministry of Education, Tongji University, Shanghai 201804, China*
[*] *Email: xiangdongxu@tongji.edu.cn (Corresponding author)*

Route choice models (RCMs) are essential for guiding traffic management and infrastructure planning. The increasing availability of GPS data has offered unprecedented opportunities for RCMs to explore large-scale and high-granularity urban mobility patterns and travelers' routing preferences. However, the lack of individual-specific features (e.g., age and income) in trajectory data leads to great uncertainty in inferring utility/disutility due to unobserved traveler heterogeneity. To address this issue, we propose a link-based Bayesian variational inverse reinforcement learning (BVIRL) model that leverages variational inference to implicitly model two main uncertainty sources, i.e., data imperfection (e.g., data scarcity) and taste heterogeneity, as disutility distributions of link-to-link transitions. This model avoids the need to explicitly incorporate specific uncertainty sources and can integrate network structural information within disutility functions via Graph Neural Networks (GNNs). These enhancements can facilitate model generalization to unpredicted scenarios and provide guidance for targeted data collection. Case studies using ride-hailing GPS data in Shanghai, China, are conducted to evaluate the model performance and to demonstrate several applications of the learned disutility distributions. Results show that the BVIRL outperforms other link-based deterministic baseline models in both prediction accuracy and generalizability under unpredicted disruption scenarios. Moreover, it is found that some high-class roads can exhibit great uncertainty in their disutility despite equipped with sufficient trajectory data, which indicates that the uncertainty is largely due to travelers' taste heterogeneity. Therefore, it is important to consider the impact of data imperfection and taste heterogeneity to help improve model accuracy and stability in predicting traffic flow patterns.

Keywords: route choice modeling, uncertainty modeling, inverse reinforcement learning, variational inference, graph neural network

____________________ ____________________ ____________________

As at December 7, 2024

# A MULTI-CONTEXT AWARE HUMAN MOBILITY PREDICTION MODEL BASED ON MOTIF-PRESERVING TRAVEL PREFERENCE LEARNING

A. Yong CHEN [a], B. Ningke XIE [a], C. Haoge XU [a], D. Xiqun CHEN [a,b,c*]
and E. Der-Horng LEE [b]
[a] *Institute of Intelligent Transportation Systems, College of Civil Engineering and Architecture, Zhejiang University, Hangzhou, China*
[b] *Zhejiang University–University of Illinois Urbana-Champaign Institute, Haining 314400, China*
[c] *Zhejiang Provincial Engineering Research Center for Intelligent Transportation, Hangzhou 310058, China*
**Email: chenxiqun@zju.edu.cn (Corresponding author)*

Accurately predicting human mobility is crucial for various applications, e.g., transportation services, epidemic control, and advertisement recommendation. Although numerous sequential modeling based methods (e.g., recurrent neural networks) have been proposed for human mobility prediction, accurately modeling individuals' high-order travel preferences and the influence of social neighbors on their travel decisions remains challenging. In this paper, we construct a novel multi-context aware model for next location prediction, which aggregates multi-dimensional contextual features, including individual preferences, social relations, and activity-location associations. First, we define activity prediction as an auxiliary task and propose an activity-location association pruning method to mitigate the impact of data sparsity on model prediction. Second, we present a novel motif-preserving individual travel preference learning method that leverages a motif-induced hypergraph convolutional network to capture high-order travel preference features explicitly. Third, we identify virtual social neighbors with similar preferences based on individual travel preference learning results, and design a new social gated fusion structure to model the influence of social neighbors on individual travel choices. Finally, experimental results on two real-world travel datasets demonstrate the superiority of the proposed model over baseline models. Our proposed universal method can be seamlessly integrated with other sequential prediction models to improve the accuracy and stability of human mobility prediction.

Keywords: Human mobility; location prediction; motif; hypergraph convolutional network; social relations

# POWERING THE RIDE: A DATA-DRIVEN APPROACH TO UNCOVERING THE POTENTIAL CHARGING DEMAND FOR ELECTRIC RIDE-HAILING VEHICLES

A. Zhicheng JIN [a] and B. Xiaotong SUN [b,c*]
[a] *Department of Electrical and Electronic Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
[b] *Intelligent Transportation Thrust, Systems Hub,*
*The Hong Kong University of Science and Technology (Guangzhou), Guangzhou, China*
[c] *Department of Civil and Environmental Engineering,*
*The Hong Kong University of Science and Technology, Hong Kong SAR, China*
**Email: xtsun@ust.hk (Corresponding author)*

This study conducts a spatial analysis of the potential charging demand for electrified ride-hailing in Shanghai, a pioneering city in transportation electrification. Leveraging extensive trip data from over 13,000 electric vehicles, the spatial clustering of potential charging demand across 2568 hexagonal grids is analyzed. The Moran's coefficient reveals a significant spatial autocorrelation, indicating proximity between high-demand areas. Spatial regression models identify the significant built environment and travel-related variables influencing potential charging demand. The density of metro, bus stations, residential communities, catering establishments, etc., are found to be significantly positive variables. The distances to airports and train stations and the density of medical facilities are negatively correlated with the potential charging demand. The spatial spillover effects of these variables are also estimated using the functions of direct, indirect, and total effects. The spatial panel data model further verifies the temporal dependence of potential charging demand. The spatial heterogeneity analysis reveals the non-stationarity of the spillover effects of three variables: bus, residence and catering. In addition, urban centers face high demand but limited charger availability, while suburban areas exhibit sufficient charger supply but require longer detours. This study's results could help verify the spatial autocorrelation of potential charging demand of electrified ride-hailing and explore significant built environment variables influencing it, contributing to the sustainable integration of electrified ride-hailing into urban transportation systems.

Keywords: Electrified ride-hailing, Charging demand, Spatial analysis, Built environment, Urban mobility

# ON THE VALUE OF ORDERLY ELECTRIC VEHICLE CHARGING IN CARBON EMISSION REDUCTION

A. Zhi LI [a, b, c], B. Zhibin CHEN [a, b*], C. Hailong LI [d], D. Chenghe GUAN [b] and E. Minghui ZHONG [e]

[a] *Shanghai Frontiers Science Center of Artificial Intelligence and Deep Learning, NYU Shanghai, People's Republic of China, 567 Yangsi West Road, Shanghai, 200124, China*

[b] *Shanghai Key Laboratory of Urban Design and Urban Science, NYU Shanghai, 567 Yangsi West Road, Shanghai, 200124, China*

[c] *Department of Civil and Urban Engineering, New York University, 6 MetroTech Center, Brooklyn, NY 11201, United States*

[d] *School of Business Society and Engineering Mälardalens Högskola, Akademin för ekonomi samhälle och teknik, Box 883, Västerås, SE 72123, Sweden*

[e] *Shanghai Electric Vehicle Public Data Collecting, Monitoring, and Research Center, 888 Moyunan Road, Shanghai, 201805, China*

[*] *Email: zc23@nyu.edu (Corresponding author)*

This study addresses the critical issue of how electric vehicle (EV) charging schedules can influence carbon emissions associated with the charging process. Our primary research question was to determine whether orderly charging of EVs could lead to a significant reduction in carbon emissions without altering drivers' travel routines. To tackle this, a bi-level model was developed: the upper level focused on optimizing EV charging schedules to minimize overall carbon emissions, while the lower level aimed to satisfy electricity demands with minimal cost of electricity dispatch. We utilized operational data from 3,777 battery EVs (BEVs) in Shanghai over an 11-month span, alongside local power plant information. Our findings revealed that BEVs in Shanghai produced 1,176,637 tons of carbon emissions within this period, averaging 73 gCO2/km per vehicle. Implementing structured charging schedules for all BEVs in Shanghai could potentially reduce these emissions by up to 39%. Further sensitivity analyses indicated that enhancements such as increasing battery capacity or integrating wind power could significantly boost emission reductions. Conversely, augmenting power plant flexibility might reduce the effectiveness of orderly EV charging. This research underlines the substantial impact that well-planned EV charging schedules can have on urban carbon emissions, offering key insights for sustainable urban development and EV policy formation.

Keywords: Carbon emission reduction, Electric vehicle, Orderly charging, Power plant dispatch, Data driven

# AN INTEGRATED LANE WIDTH DESIGN METHOD CONSIDERING THE DEDICATED LANE FOR ELECTRIC BICYCLES

A. Yuzheng GUO [a], B. Jichen ZHU [a*], C. Yuqi SHI [a] and D. Xiaoguang YANG [a]

[a] *Key Laboratory of Road and Traffic Engineering of the Ministry of Education, Tongji University, Shanghai, China, and 201804*

[*] *Email: jcihen_zhu@tongji.edu.cn (Corresponding author)*

Electric bicycles are becoming increasingly popular worldwide due to their convenience and cost-effectiveness. However, due to the higher desired speed, electric bicycles will frequently take lane-changing behavior in the traditional bicycle lane. It will greatly increase safety hazards and bring negative effects on traffic throughput. The dedicated lanes design for electric bicycles is a rising solution to separate the electric bicycles, bikes, and vehicles. This study proposes an integrated lane width design method for urban road. We firstly analyze the capacity of the dedicated lane for electric bicycles with different widths. Then, we model the integrated design as a Mixed-Integer Linear Program (MILP), aiming to further explore the potential capacity of the existing road space. We evaluate our design method on a real-world road. The results demonstrate that our proposed design method can significantly explore the potential capacity of the existing road space compared to existing designs. Sensitivity analysis is further conducted to assess the effectiveness of our proposed design method under different road widths and traffic demands. The results indicate that the integrated design method can be a valuable tool for policymakers in evaluating the feasibility of dedicated lanes for electric bicycles.

Keywords: Lane Width Design, Dedicated Lanes for Electric Bicycles, Mixed-Integer Linear Program, Feasibility Analysis

# AN AUCTION-BASED DRIVER ASSORTMENT APPROACH FOR UNATTRACTIVE RIDEHAILING ORDERS CONSIDERING THE DRIVERS' PREFERENCES

A. Yitong ZHANG [a], B. Qian GE [a*] and C. Ke HAN [b]

[a] *School of Transportation and Logistics, Southwest Jiaotong University, Chengdu, Sichuan, China*

[b] *School of Economics and Management, Southwest Jiaotong University, Chengdu, Sichuan, China*

**Email: geqian@swjtu.edu.cn (Corresponding author)*

Ride-hailing platforms rely on assigning tasks to drivers through one-to-one matching problems to maximize profit while meeting rider service requirements. However, this approach often overlooks drivers' preferences, impacting order completion rates. In China, a recent escalation in conflicts among drivers and the platforms over unattractive long-distance orders highlights the need for fair matching and payment methods considering drivers' choices. To address this, we propose an auction-based incentive mechanism embedding the discrete choice model into combinatorial auctions. Our approach constructs a many-to-many map of drivers and riders, followed by a combinatorial programming model to select the optimal driver subset for each order. A greedy approximation algorithm is developed that leverages the submodularity of the problem. The payment to each driver is then determined by a generalized second-price rule. The proposed mechanism ensures profitability, individual rationality, and incentive compatibility. Validation using Chengdu, Sichuan network data confirms its efficacy.

Keywords: Incentive Mechanism; dispatching; greedy algorithm; generalized second-price auction

# ONLINE OPTIMIZATION OF INTEGRATED CHARGING AND PARKING SERVICES CONSIDERING VEHICLE RELOCATION

A. Jie LIN [a] and B. Fangni ZHANG [a*]

[a] *Department of Industrial and Manufacturing Systems Engineering, University of Hong Kong, Hong Kong, China*

[*] *Email: fnzhang@hku.hk (Corresponding author)*

This paper investigates the online optimization of integrated charging and parking services in a parking lot with both charging and parking spaces. We leverage emerging autonomous valet parking technologies to enable vehicle relocation operations during service durations. This relocation flexibility allows for releasing occupied charging spaces upon completing a vehicle's charging process. Furthermore, when a vehicle requiring charging finds no available charging spaces, it can temporarily be situated in a parking space and subsequently relocated to a charging space as soon as one becomes available. Such operations have the potential to improve charging facility utilization and the service level. We propose a rolling horizon optimization framework to manage parking lot operations. In each time slot, new reservation requests are received, and decisions are made regarding their acceptance and service schedule. The schedules are dynamically reoptimized in later time slots to account for new information such as new reservations and order cancellations. We develop three online strategies to derive operational decisions, with an offline optimization model as a benchmark to assess their performance. Numerical experiments are conducted to evaluate the performance of these strategies under various scenarios. The results demonstrate the significant advantages of non-myopic strategies over myopic ones when configured with proper parameter values. Moreover, incorporating vehicle relocation yields considerable profit improvements and charging facility utilization enhancements. Finally, a comprehensive sensitivity analysis investigates the impact of varying key parameter values on strategy performance and the magnitude of system improvements enabled by vehicle relocation operations.

Keywords: Electric vehicles, Integrated parking and charging lot, Vehicle relocation, Rolling horizon optimization, Online strategy

# DESIGN OF SMART ELECTRIC VEHICLE CHARGING SERVICES UNDER DEMAND AND RENEWABLE ENERGY UNCERTAINTIES: A TWO-STAGE STOCHASTIC OPTIMIZATION MODEL

A. Lin YU [a], B. Yanyan DING [b] and C. Sisi JIAN [a*]

[a] *Department of Civil and Environmental Engineering,*

*The Hong Kong University of Science and Technology, Hong Kong SAR, China*

[b] *Department of Logistics and Maritime Studies,*

*The Hong Kong Polytechnic University, Hong Kong SAR, China*

[*] *Email: cesjian@ust.hk (Corresponding author)*

With the increasing number of electric vehicles (EVs), the transition to renewable energy-based EV charging services is crucial for decarbonizing transportation systems. However, this transition poses challenges for charging service providers (CSPs) due to additional investment costs associated with installing green electricity production devices such as solar panels, as well as the fluctuating availability of renewable energy which brings uncertainty in green electricity yields. To incentivize CSPs to adopt renewable energy technology, local government agencies (GOVs) resort to providing monetary rewards to CSPs who can offer green electricity to the grid. We model a two-stage stochastic optimization problem to present how CSPs design charging services in response to the proposed GOV's intervention, taking into account both the uncertain demand for EV charging services and the uncertain supply of renewable energy. Specially, CSPs need to make long-term investment decisions on the types and quantities of smart chargers at the first stage and then determine the charging service price at the second stage. Building on the stochastic model, we characterize the impact of local Gov's incentives and local weather condition characteristics on renewable energy technology investment under dynamic market demand. We prove the well-posedness of the proposed model and develop a tailored bender decomposition method to compute the optimal decisions of CSPs. We validate the proposed model in a comprehensive case study for major cities in the USA and China, demonstrating that the proposed incentives provided by local GOVs to CSPs can effectively promote an energy transition in the charging service business.

Keywords: Energy policy, Electric vehicle charging service, Demand Uncertainty, Supply Uncertainty, Stochastic Programmings

# INTEGRATING UAV TECHNOLOGY IN LAST-MILE DELIVERY: A CASE STUDY OF THE TOPICAL IN INDIA AND ITS IMPLICATIONS FOR SMART URBAN MOBILITY

A. Yi-lin LIU [a,*]

[a] *School of Intelligent Finance and Business, Entrepreneur College,*
*Xi'an Jiaotong-Liverpool University, Suzhou, China.*
**Email: Yilin.Liu21@student.xjtlu.edu.cn (Corresponding author)*

Transportation is pivotal in social production, improving goods movement within the production and circulation phases. In today's information era, intelligent mobility and transportation are increasingly adopted, enhancing delivery system efficiency, and crucial for commodity circulation. Intelligent transportation systems (ITS) advance smart cities by utilizing sensor data to optimize urban mobility and supply chain management. ITS benefits include real-time traffic/weather information and reduced distribution costs, potentially altering magazine delivery and distribution. Drone use could revolutionize delivery, bypassing geographic constraints. Nonetheless, this integration brings challenges like balancing automation-induced job loss against new technological roles. As delivery models progress with intelligent systems, companies could benefit from increased efficiency and customer satisfaction while considering socio-economic changes. Focusing on The Topical's research in India, this paper examines the feasibility of UAVs in last-mile delivery, aiming to enlighten the last supply chain segment.

Keywords: Last-Mile delivery, Unmanned aerial vehicles (UAV), Supply chain management, Intelligent transportation systems (ITS)

As at December 7, 2024

# JOINT OPTIMIZATION OF INCENTIVE AND ROUTING STRATEGIES IN CROWDSOURCED LAST-MILE DELIVERY

A. Dongze LI [a] and B. Fangni ZHANG [a*]

[a] *Department of Industrial and Manufacturing Systems Engineering,*
*The University of Hong Kong, Hong Kong SAR, China*
[*] *Email: fnzhang@hku.hk (Corresponding author)*

The growing demand for efficient last-mile delivery has given rise to a new urban logistics paradigm – crowdshipping – which involves engaging the general public in parcel transportation by offering incentives to the "crowd" during their daily trips. There is uncertainty regarding whether participants will accept an assigned delivery order, along with its accompanying reward from the platform. This uncertainty must be considered when the platform formulates decisions pertaining to order allocation and route optimization. This study addresses the design of incentive strategies for crowd carriers considering this uncertainty and explores collaborative routing decisions with professional couriers to minimize overall platform costs, including both incentive and routing expenses. We model this problem as a stochastic optimization problem that determines the optimal incentive costs for each crowd carrier, which in turn influences their initial probability of participation. Additionally, the model optimizes order allocation and routing strategies involving both crowd carriers and professional couriers. The detour distances for crowd carriers are considered, which further impacts their actual participation probabilities. As the model is NP-hard, we develop an Adaptive Large Neighborhood Search (ALNS)-based algorithm that significantly improves solving efficiency. Through numerical experiments, we identified the optimal incentive and routing strategies under different relationships between incentive costs and initial participation probabilities of crowd carriers. Our findings emphasize the varied roles of different crowd carriers in the delivery ecosystem and highlight the importance of tailored incentive strategies to enhance overall delivery efficiency.

Keywords: crowdshipping, incentive mechanism, vehicle routing problem

# TECHNOLOGICAL ADVANCES IN RURAL LOGISTICS: THE BENEFITS OF ELECTRIC CABLE CARS

A. Yiqing LIANG [a*] and B. Becky P.y. LOO [a]

[a] *Department of Geography, The University of Hong Kong, Hong Kong SAR, China*

[*] *Email: lyiqing@connect.hku (Corresponding author)*

While the growth of e-commerce has transformed rural logistics in fundamental ways, the application of electric cable cars in rural logistics remains underexplored. This study investigates the potentials of electric cable cars in reducing transport carbon emissions and enhancing rural sustainability through an in-depth study of detailed operations of an electric cable car system (with 22 logistics stations) in Anyuan County of Jiangxi Province over a period of 32 months from December 2020 to July 2023. This study employs a detailed carbon emission calculation methodology, considering factors such as characteristics of different transport vehicles, goods weight, and transport distance, to compare carbon emissions between a hybrid transport model electric cable cars and typical rural road transport modes of motorcycles and light trucks and a road-only transport model. More than 26,928 transactions, together with their product types, are analyzed. Results indicate that electric cable cars have significant emission reduction potential in rural logistics. The study also categorizes products in rural logistics as rural small business, consumer goods, and productivity-enhancing goods, and analyzes transaction characteristics and their impact on rural wellbeing across these categories. Findings indicate that e-commerce platforms promote diverse goods circulation in rural areas, positively affecting villagers' quality of life and economic income. The study is among the first to provide scientific evidence on the role of technological advances in supporting rural transport decarbonisation and wellbeing.

Keywords: Rural Logistics, Electric Cable Cars, Carbon Emissions, Transport Decarbonisation, Rural Wellbeing

# COORDINATIVE DISPATCHING OF SHARED AND PUBLIC TRANSPORTATION UNDER PASSENGER FLOW OUTBURST

A. Xiaohan WANG [a], B. Xiqun (Michael) CHEN [a*], C. Chi XIE [b]
and D. Taesu CHEONG [c]

*[a] Institute of Intelligent Transportation Systems, College of Civil Engineering and Architecture, Zhejiang University, Hangzhou, China*

*[c] School of Transportation Engineering, Tongji University, Shanghai, China*

*[d] School of Industrial Management Engineering, Korea University, Seoul, South Korea*

**Email: chenxiqun@zju.edu.cn (Corresponding author)*

In the passenger flow outburst area (e.g., metro emergency, dispersal of sporting events, and concerts), passengers put forward large demand for ride-sourcing services. Insufficient ride-sourcing supply of the area induces increasing matching time, and the ride-sourcing influx from outside picking up passengers leads to heavier road traffic congestion in the flow outburst area. To solve this problem, we propose a novel coordinative dispatching method of ride-sourcing and public transportation, in which subsidies and buses are provided for passengers in flow outburst areas to encourage taking other public transportation to low passenger flow areas first and then taking ride-sourcing to their destinations. In this paper, there are two options for passengers: (a) wait for ride-sourcing to pick them up; (b) take other public transportation first and then take ride-sourcing. To obtain the optimal dispatching and subsidy schemes, we develop a bi-level mixed integer programming model based on network flow theory and design the corresponding iterative algorithm to solve it. Considering the high uncertainty of ride-sourcing demand in the area, we further develop a robust optimization model to obtain more reliable schemes. Case studies based on a real-problem-scale dataset are conducted. The results demonstrate that our approach can be carried out in real time, and encouraging passengers to take multi-modal transit shows great potential in reducing affected users' delays. The robust optimization model offers a more reliable and competitive solution when demand varies widely. Our method offers a win-win-win way for passengers, ride-sourcing service providers, and public transportation systems.

Keywords: Passenger flow outburst, on-demand ride services, multi-modal transit, space-time expanded network, robust optimization

As at December 7, 2024

# EVALUATION OF NOVEL MOBILITY SERVICE MIXED RIDE-SHARE WITH SHUTTLE BUS FOR A SHOPPING CENTER IN SUBURBAN RESIDENTIAL AREA

A. I. MORITA [a], B. A. MIZUNO [a], C. H. HASADA [a, b*], D. S. KITAMURA [a] and E. R. KANAMORI [c]
[a] *The Institute of Behavioral Sciences, Japan*
[b] *Institute of Industrial Science, The University of Tokyo, Japan*
[c] *Institutes of Innovation for Future Society, Nagoya University, Japan*
[*] *Email: hasada@iis.u-tokyo.ac.jp (Corresponding author)*

AI on-demand services, which are demand responsive transport services that use artificial intelligence to optimize routes and dispatch vehicles in real time, are gradually gaining traction in various areas in Japan. While the services enable efficient ride-sharing, in practice they often result in inefficient piston transport of a single passenger. In this study, we propose and evaluate a novel "Semi-scheduled DRT" operation, which is mixed ride-sharing with shuttle bus. Unlike the conventional approach, the shuttles operate according to regular schedules for on-demand pick-up and drop-off. We focus on a case study in Kozoji New Town, a typical suburban area in Japan, where the shuttles operate between a shopping center and residential areas. Our simulation results show that the " Semi-scheduled DRT" operation outperforms the standard on-demand operation. By encouraging passengers to adhere to fixed pick-up and drop-off times, we observe increased profitability and improved overall system efficiency. This finding underlines the fundamental principle of public transport: the collective effort of citizens to stagger their departure/arrival times leads to a more efficient and sustainable transportation system. It shows how coordinated travel behavior to optimize urban mobility could pave the way for a smarter and more efficient public transport system, not just AI on-demand services.

Keywords: demand responsive transport, ride-sharing, simulation, public transport

# GNN-BASED EXPLAINABLE TRAFFIC CONGESTION PREDICTION WITH GNNEXPLAINER

A. Yuhang YANG [a,b] and B. Shuyang ZHANG [a,b*]
[a] *School of Transportation and Logistics Engineering,*
*Wuhan University of Technology, China*
[b] *Engineering Research Center of Transportation Information and Safety,*
*Ministry of Education, China*
**Email: zhangshuyang@whut.edu.cn (Corresponding author)*

Traffic congestion prediction is instrumental in traffic management. Graph Neural Network (GNN)-based methods have emerged as a feasible solution for traffic prediction due to their high potential to capture spatial information and high accuracy. However, the lack of transparency and explainability of these approaches obstruct further research. For instance, it is difficult to explain the causes of congestion and provide a basis for relieving traffic congestion. In this work, we address this challenge by utilizing the GNNExplainer, a general approach designed to offer interpretable explanations for the prediction of GNN-based models. While we predict traffic congestion through a graph neural network (GNN) model, the GNNExplainer is used to identify the importance of the input graph structures of the trained GNN model and generate explanations of the predicted traffic congestion. Experiments on a real-world dataset of the CalTrans Performance Measurement System (PeMS) demonstrate that our approach can accurately recognize important traffic links in the congestion formation process. Using quantitative evaluation metrics further confirms the high level of explanation accuracy achieved.

Keywords: Traffic congestion prediction; Graph neural network; GNNExplainer; Explainability

# A NEW METHOD FOR NON-DESTRUCTIVE DIAGNOSIS OF SEMI-RIGID BASE DAMAGE CONDITION OF ASPHALT PAVEMENT

A. Lulu YANG [a*], B. Zhang CHEN [a*], C. Di ZHAO [a], D. Yingdong YAO [b] and E. Tianxu LI [c]

[a] *Key Laboratory of Road and Traffic Engineering of the Ministry of Education,*

[b] *Shanghai Road Transportation Development Center, Shanghai, China*

[c] *SCEGC NO.5 Construction Engineering Group Company Ltd, Xi'an, China*

**Email: tjyanglulu@163.com; zchen@tongji.edu.cn (Corresponding authors)*

As semi-rigid base is the primary source of the structural bearing capacity of pavements, diagnosing its condition is crucial for informed decision-making regarding pavement maintenance and repair. To achieve non-destructive diagnosis of semi-rigid base damage condition, this paper utilizes the test results of falling weight deflectometer (*FWD*) to back calculate the base modulus of in-service pavement. In addition, with the structural behavior equation applied, the modulus decay trend under load is analyzed to determine the non-damage modulus ($E_0$). The base modulus ratio (*BMR*) is used as the evaluation index for assessing base damage condition. Finally, an engineering case study is carried out based on Hengde Expressway. The new method achieves a diagnostic coincidence rate of 79% when comparing non-destructive diagnostic results with on-site drilling core sampling. This accuracy can provide valuable decision support for determining whether the semi-rigid base layer needs renovating in pavement maintenance.

Keywords: road engineering; semi-rigid base layer; modulus back-calculation; nondestructive diagnosis model; damage condition

# MECHANISM DESIGN FOR COORDINATING VEHICLE-BASED MOBILE SENSING TASKS WITHIN THE RIDE-HAILING PLATFORM

A. Shenglin LIU [a], B. Qian GE [a*] and C. Ke HAN [b]

[a] *School of Transportation and Logistics, Southwest Jiaotong University, Chengdu, China*

[b] *School of Economics and Management, Southwest Jiaotong University, Chengdu, China*

**Email: geqian@swjtu.edu.cn (Corresponding author)*

This paper evaluates the benefit of integrating vehicle-based mobile crowd-sensing tasks into the ride-hailing system through the collaboration between the data user and the ride-hailing platform. In such a system, the ride-hailing platform commissions high-valued sensing tasks to idle drivers who can undertake either ride-hailing or sensing requests. Considering the different service requirements and time windows between sensing and ride-hailing requests, we design a staggered operation strategy for ride-hailing order matching and the sensing task assignment. The auction-based mechanisms are employed to minimize costs while incentivizing driver participation in mobile sensing. To address the budget deficit problem of the primal VCG-based task assignment mechanism, we refine the driver selection approach and tailor the payment rule by imposing additional budget constraints. We demonstrate the benefits of our proposed mechanism through a series of numerical experiments using the NYC Taxi data. Experimental results reveal the potential of the mechanism for achieving high completion rates of sensing tasks at low social costs without degrading ride-hailing services. Furthermore, drivers who participate in both mobile sensing tasks and ride-hailing requests may gain higher income, but this advantage may diminish with an increasing number of such drivers and higher demand for ride-hailing services.

Keywords: Mechanism design, mobile crowd-sensing, ride-hailing system

## POSTER SESSION 4

# TRTR: A VERSATILE PRE-TRAINED LARGE TRAFFIC MODEL BASED ON TRANSFORMER FOR CAPTURING TRAJECTORY DIVERSITY IN VEHICLE POPULATION

A. Ruyi FENG [a,b*], B. Huihuang ZHU [a], C. Zhibin LI [a*] , D. Bowen LIU [a] and E. N.N.SZE [b*]
[a] *School of Transportation, Southeast University, China*
[b] *Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, China*
**Email: fengruyi@seu.edu.cn; lizhibin@seu.edu.cn; tony.n.n.sze@connect.polyu.hk (Corresponding authors)*

The current physical model struggles to capture the diversity of vehicle trajectories due to its limited parameter scale. The emerging Transformer architecture offers a promising solution with its parallel computation capabilities, allowing for an expanded parameter set. However, training such large models presents challenges. Data organization and training task design are crucial for optimizing the Transformer's performance. In this study, we propose a Transformer training mode for vehicle trajectory prediction, focusing on detailed interaction learning. We first create a data structure tailored to the attention mechanism, followed by a noise injection training mode for the prediction task. Experimental comparisons with other training modes demonstrate the effectiveness of our approach. The predicted trajectories were evaluated for accuracy and driving intention, achieving an RMSE of 0.6059 compared to the ground truth. Furthermore, the predicted trajectory shows both active lane change and inserted interaction.

Keywords: Transformer, Trajectory, Traffic Prediction, Deep Learning

# LARGE LANGUAGE MODEL-ENHANCED REINFORCEMENT LEARNING FOR GENERIC BUS HOLDING CONTROL STRATEGIES

A. Jiajie YU [a], B. Yuhong WANG [a] and C. Wei MA [a*]
[a] *Civil and Environmental Engineering, The Hong Kong Polytechnic University*
*Hung Hom, Kowloon, Hong Kong Special Administrative Region, China*
**Email: wei.w.ma@polyu.edu.hk (Corresponding author)*

Bus holding control is a crucial strategy for maintaining stability and improving the operational efficiency of bus systems. Reinforcement Learning (RL), as a data-driven method, has demonstrated promising performance in deriving the bus holding control strategy, outperforming traditional model-based methods. Specifically, the performance of RL agents is directly influenced by the design of the reward function. However, decomposing sparse and overall goals in real-world control tasks into dense learning signals for RL is challenging, normally requiring extensive manual trial-and-error. This study introduces an automatic reward generation paradigm, leveraging the in-context learning and reasoning capabilities of Large Language Models (LLMs), to tackle this challenge for RL-based control strategies. This new paradigm, termed the LLM-enhanced RL, comprises several LLM-based modules: reward initializer, reward modifier, performance analyzer, and reward refiner. These modules cooperate to initialize and iteratively improve the reward function according to the feedback from training and test results for the specified RL-based task. Ineffective reward functions generated by the LLM are filtered out to ensure the stable evolution of the RL agents' performance over iterations. To evaluate the feasibility of the proposed LLM-enhanced RL paradigm, it is applied to various bus holding control scenarios, including a synthetic single-line system and a real-world multi-line system. The results demonstrate the superiority of the proposed paradigm compared to vanilla RL strategies, the LLM-based controller, and space headway-based feedback control. This study sheds light on the great potential of utilizing LLMs in various smart mobility applications.

Keywords: Large language model, Deep reinforcement learning, Bus bunching, Dynamic holding, Control strategy

# OPTIMAL TOUR LENGTH ESTIMATOR FOR VEHICLE ROUTING PROBLEMS IN REAL ROAD NETWORKS USING GRAPH NEURAL NETWORKS

A. Hongzheng SHI [a*], B. Jiguang WANG [a] and C. Jintao KE [a]
[a] *Department of Civil Engineering, The University of Hong Kong, Hong Kong SAR, China*
**Email: shihz@connect.hku.hk (Corresponding author)*

Accurate estimation of the optimal total tour length for the Vehicle Routing Problem (VRP) within real road networks is crucial for enhancing logistics and transportation efficiency. Traditional optimization algorithms and machine learning methods typically require pre-computation of the shortest path lengths between any two points on the road network, a process that can be exceedingly time-consuming. Utilizing Euclidean or Manhattan distances based directly on coordinates often results in significant errors, as the actual shortest path on a road network is frequently affected by complexities such as detours and one-way streets, which can lead to substantial deviations from distances calculated using coordinates alone. Consequently, this paper introduces a novel estimator that leverages a graph neural network to predict the optimal total VRP tour length. This estimator employs a clustering-based method to aggregate road network data across multiple levels and integrates this multilevel road network information with the locations of depot station and customer points to enhance prediction accuracy using graph neural networks. Numerical experiments conducted on the Chengdu road network demonstrate that our approach can accurately and efficiently estimate VRP tour length for scenarios involving randomly distributed field station and customer points.

Keywords: vehicle routing problem, real road network, optimal tour length estimation, graph neural network

# TRAFFIC CONFLICT ANALYSIS WITH SURROGATE SAFETY MEASURES BY LATENT REPRESENTATIONS

A. K.I. WONG [a*] and B. Jia Syuan LIN [a]
[a] *Department of Transportation and Logistics Management,*
*National Yang Ming Chiao Tung University, Taiwan*
[*] *Email: kiwong@nycu.edu.tw (Corresponding author)*

Traditional traffic safety analysis relies on statistical data of traffic crashes, requiring significant time to accumulate enough information to access improvements. In contrast, using surrogate safety measures (SSM) for traffic conflict analysis offers a proactive approach by analyzing traffic conflicts. This method involves observing road user interactions, assessing their severity using surrogate safety measures, and identifying potential conflicts with safety implications. However, identifying traffic conflicts with SSMs involves selecting appropriate measures and thresholds, which can lead to irrelevant events or misinterpretations if not carefully chosen. This study proposes a novel method for traffic conflict identification using latent representation learning. It addresses the limitations of current SSM approaches, particularly in Taiwan's traffic environment with passenger cars and a high ratio of scooters in the mixed traffic environment. The research applies latent representation clustering with deep learning to an open-sourced vehicle trajectory dataset from Taiwan, and different models are developed for the vehicle interaction combinations, including car-scooter, car-car, and scooter-scooter. The method effectively learned and classified interaction features, revealing distinct conflict characteristics and spatial-temporal distributions across various intersections. The results demonstrate the effectiveness of the approach and provide a detailed assessment of traffic safety based on vehicle interaction patterns.

Keywords: Surrogate safety measures (SSM), Traffic conflicts, Vehicle trajectory data, Latent representation learning, Deep learning

# INJURY SEVERITY ANALYSIS OF ROAD TRAFFIC ACCIDENTS IN HONG KONG: A COMPARATIVE STUDY BEFORE AND DURING THE COVID-19 PANDEMIC

A. Qiaoqiao REN [a], B. Chak Kei LI [a] and C. Min XU [a*]

[a] *Department of Industrial and Systems Engineering, The Hong Kong Polytechnic University, Hong Kong SAR, China*

[*] *Email: xumincee@gmail.com (Corresponding author)*

Road traffic accidents represent a substantial public health challenge in Hong Kong, resulting in significant daily casualties. Additionally, the outbreak of the COVID-19 pandemic has brought about unprecedented changes in the traffic volume, driver behavior, and sample selectivity, which could alter the transportation pattern and influence the injury severity of road traffic accidents. Therefore, understanding the impact of COVID-19 on transportation patterns is crucial for gaining insights into the implementation of road safety measures. Using a dataset collected from the Hong Kong Transport Department and the Hong Kong Police Force's Traffic Information System, this study employed the Random Forest to investigate impacts of multiple factors associated with crashes, drivers, vehicles, environment, and districts. Besides, feature importance was extracted and compared for examining the influence of contributing factors on severities of accidents before (2018-2019) and during the COVID-19 pandemic (2020-2022). The results indicate that the Random Forest algorithm demonstrated a robust prediction performance, achieving an average accuracy of 92.46%, a precision of 92.56%, a recall of 99.8%, and an F1-score of 96%. It was also found that the type of collision and vehicle movements had significant impacts in the pre-pandemic period, while the location of injury had a high contribution during the pandemic period. Besides, districts in Yau Tsim Mong, Yuen Long, Sha Tin, Tai Po, Kwun Tong, and Eastern should pay more attention for developing road safety measures. The insights presented in this paper have the potential to serve as valuable references to enhance road traffic safety in Hong Kong.

Keywords: Traffic safety, Injury severity analysis, COVID-19 pandemic, Random forest, Feature importance

# V-RP3D: ENHANCING ROADSIDE LIDAR-BASED PERCEPTION THROUGH DOMAIN GENERALIZATION FROM VEHICLE PERSPECTIVE IN 3D OBJECT DETECTION.

A. Chin Long NG [a], B. Yafei WANG [a*], C. Bowen WANG [a], D. Zexing LI [a] and E. Ruoyao LI [a]
[a] *School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai, China*
[*] *Email: mail: wyfjlu@sjtu.edu.cn (Corresponding author)*

Roadside Light Detection and Ranging (LiDAR) is widely used to record high-precision traffic data which is crucial for intelligent transportation systems (ITSs) to elevate traffic safety in rapidly developed cities. However, the placement of roadside LiDAR is static and restricted by the specific infrastructure layout in each roadside scenario, where the homogeneity of the background point cloud distribution leads to overfitting of the data-driven 3D detection model trained on specific roadside scenario data. In addition, establishing large-scale roadside datasets in each urban area is very time-consuming and labor-intensive. Compared to roadside data, driving car data obtained by onboard LiDAR has different fields of view and various object feature distributions. Nevertheless, its relative wealth of feature information has the potential to enhance the generalization ability and performance of the roadside detection model. To this end, this article attempts to propose a domain adaption framework for vehicle-to-roadside 3D object detection (V-RP3D) to address the domain gap introduced by various point cloud feature distributions. In particular, we exploit a knowledge distillation framework for driving car and roadside data, wherein we further enforce the consistency of the predicted boundary boxes to refine the pre-trained model by aligning the data into the same perspective, Bird's-Eye View (BEV). Furthermore, we also utilized the labeled source data obtained from the vehicle perspective to preserve the wealth of object feature information for improving the robustness of the roadside 3D detection model. Experimental results indicate that our model maintains competitive performance in widely adapted vehicle and roadside datasets.

Keywords: Unsupervised Domain Adaptation, Roadside Object Detection, Point Clouds

# REPRESENTATION ENHANCED BEHAVIOR PLANNING USING VECTOR QUANTIZED ENCODING FOR AUTONOMOUS DRIVING

A. Jingda WU [a], B. Chao HUANG [b*] and C. Hailong HUANG [a]
[a] *Department of Aeronautical and Aviation Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
[b] *Department of Industrial and Systems Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
[*] *Email: jingda.wu@polyu.edu.hk; hchao.huang@polyu.edu.hk (Corresponding author)*

Behavior planning for autonomous vehicles (AVs) poses a significant challenge, especially in extracting comprehensive environmental perception information through neural network-based planning agents. Unlike traditional approaches that rely on larger-scale neural networks, this paper introduces an efficient representation enhancement scheme using a vector quantizer (VQ) mechanism. We integrate the VQ-variational autoencoder architecture with reinforcement learning (RL)-based planning strategies to develop a novel VQ-RL method. This method involves mapping the output of the state encoder to a finite set of discrete embedding vectors that can more effectively represent the environment. These vectors serve as inputs to the decoder, which generates tactical behavior actions based on these latent abstract representations. To improve effectiveness, we introduce a dual-objective learning method that updates both the optimal value objective for RL and the VQ-based environmental representation objective simultaneously. The algorithm considers not only the conventional optimal value objective for RL but also includes the environmental representation enhancement through the reconstruction target and the vector quantizer objective. We demonstrate the effectiveness of the proposed VQ-RL method through its application to the lane-changing task for AVs. Comparisons with state-of-the-art standard RL methods show that our strategy, enhanced by VQ-based representation, leads to a deeper understanding of the autonomous driving environment and significantly improves behavior planning performance.

Keywords: Autonomous driving, Behavior planning, Representation, Reinforcement learning, Vector quantizer

# AUTOMATED ENERGY-EFFICIENT ADJUSTMENT OF ADAPTIVE CRUISE CONTROL SPEED SETTING USING NEAR REAL-TIME DOWNSTREAM VEHICLE TRAJECTORY DATA

J. CARPIO [ab*]
[a] *College of Engineering, National University, Manila, Philippines*
[b] *Department of Civil and Environmental Engineering, University of California, Berkeley, California, USA*
**Email: jncarpio@national-u.edu.ph; engrjoycarpio@berkeley.edu*

In this paper, we aimed to enhance the capability of the stock Adaptive Cruise Control (ACC) system, commonly found in modern vehicles. By enabling vehicles to communicate and share their trajectory data (speed and position), a following vehicle equipped with the same capability could utilize this information to efficiently manage its future trajectory, ultimately aiming for a more energy-efficient driving pattern. This work introduced a mechanism that leveraged live vehicle data to estimate the upcoming trajectory of another vehicle located further behind. Using this estimated trajectory, we developed a trajectory smoothing technique specifically designed for vehicles whose speed was controlled automatically by the stock ACC, where frequent speed adjustments were undesirable. The smoothed trajectory was then used to dynamically adjust the ACC speed setting, rather than adhering to a fixed high value. Both simulation and real-world testing demonstrated that the enhanced ACC system outperformed the stock ACC in terms of energy efficiency. Additionally, the vehicle equipped with the enhanced ACC positively influenced the following vehicles by dampening instabilities propagated from its leader.

Keywords: Adaptive Cruise Control, Traffic Smoothing, Downstream Traffic Estimation

# UNRAVELING PREFERENCE HETEROGENEITY IN METRO ROUTE CHOICE USING MOBILE PHONE DATA

A. Xiaolei LIU [a], B. Zhengyu DUAN [a*], C. Qing YU [b] and D. Mengyi WANG [a]
[a] *Key Laboratory of Road and Traffic Engineering of the Ministry of Education, College of Transportation Engineering, Tongji University, Shanghai 201804, China*
[b] *School of Urban Planning and Design, Peking University Shenzhen Graduate School, Shenzhen, 518055, Guangdong, China*
[*] *Email: d_zy@163.com (Corresponding author)*

Understanding passengers' route choice behavior is important for efficient metro management. Traditionally, specialized surveys have been designed to explore the factors influencing route decisions, and smart card data has been utilized to identify mobility patterns and estimate route choice models. However, both data sources cannot provide the actual travel trajectories of passengers. In contrast, mobile phone data can continuously record the spatiotemporal locations of users, presenting a new perspective for analyzing travel behavior. This study reveals route preference heterogeneity for metro users using large-scale mobile phone data. First, an algorithm is proposed to extract massive metro trips from mobile phone signaling records. Then a series of indicators are developed from travel intensity, spatial, temporal and route usage perspectives, followed by K means++ clustering to group users with similar travel patterns. Next, route attributes are derived from mobile phone data, and the Path-size logit (PSL) model is employed to estimate the route preference for different groups. Taking Shanghai metro as an example, 30.09 million trips made by 3.83 million users are extracted from one-month mobile phone data. Metro passengers are partitioned into high-frequency users, characterized by commute behavior and high dependence on metro services, and low-frequency users, who rely less on metro. They present distinct trade-offs when choosing routes, high-frequency users prioritize shorter travel time and comfortable riding experience, while low-frequency users prefer more direct routes with fewer transfers. The findings can help formulate an effective route recommendation system to optimize metro operations.

Keywords: Mobile phone data, Metro networks, Mobility patterns, Route choice, Preference heterogeneity

POSTER SESSION 5

# IDENTIFICATION OF HAZARDOUS SECTIONS IN SMALL-VEHICLE-ONLY UNDERGROUND ROADS USING 3D SIMULATION: A CASE STUDY OF THE SEOBU UNDERGROUND EXPRESSWAY

A. Hyung Joon BANG [a*], B. Youngkyun KANG [b*], C. Dohoon KIM [c*] and D. Taekyoung KIM [b]

[a] *Department of Transportation Engineering, University of Seoul, Seoul, Republic of Korea*

[b] *Technology Research Center, Hyundai Engineering & Construction Co., Ltd., Republic of Korea*

[c] *FORUM8 KOREA Co., Ltd, Republic of Korea*

[*] *Email: banghj.kr@gmail.com; ykkang@hdec.co.kr; dhkim@forum8.co.kr (Corresponding authors)*

This study proposes a method using 3D simulation to evaluate the driving safety of small-vehicle-only underground roads. These roads have unique risk factors different from conventional surface roads or all-vehicle underground roads, and the psychological factors of drivers due to the enclosed environment also play a significant role. To address these specificities, this study utilized UC-win/Road and a real vehicle simulator to construct a detailed 3D virtual reality road. A virtual driving experiment was conducted with actual drivers, collecting and analyzing detailed data such as driving speed and lane offset to identify hazardous sections of the road. The analysis revealed sections with decreased driving safety, characterized by reduced driving speed and lane departure, particularly in continuous curve sections or areas with abrupt vertical gradient changes. This study demonstrates that 3D simulation can overcome the limitations of traditional driving safety evaluation methods, providing flexible and realistic results in complex road environments. It plays a crucial role in systematically ensuring safety during the road design phase.

Keywords: Driving Safety Analysis, 3D Simulation-Based Safety Analysis, Small-Vehicle-Only Underground Roads, Hazardous Section Identification

# TRAFFIC ORIGIN–DESTINATION MATRICES PREDICTION WITH CONSIDERATION OF TRAVEL FREQUENCY

A. S.L. HUANG [a], B. C. ZHANG [a*] and C. J. ZHAO [a]

[a] *Department of Traffic Engineering, University of Shanghai for Science and Technology, Shanghai, China*

**Email: chengzhang@usst.edu.cn (Corresponding author)*

Accurate prediction of traffic origin–destination (OD) matrices plays an important role in traffic management and urban development. The existing studies on OD matrix prediction primarily focus on time series prediction techniques, while the influences of individual activities have long been overlooked. To address this issue, a traffic OD matrix-prediction method that considers individual travel frequencies is proposed. The travel frequencies of the vehicles are determined using license plate recognition data. Based on travel frequency, all vehicles are classified into several categories using the K-means method. Subsequently, historical OD matrices for different vehicle categories are input into multiple deep learning models. These deep learning models are trained separately to predict the traffic OD matrices with respect to different levels of travel frequency. By aggregating these OD matrices, a short-term prediction of the total traffic OD matrices can be obtained. The proposed method is validated using real license plate recognition data collected from a specific area of Liuzhou City, China. The results demonstrate that the proposed method outperforms existing methods that do not consider travel frequency, with a reduction of 16.8% in mean absolute errors, a decrease of 16.2% in root mean square errors, and a 27.6% increase in R-squared values on average.

Keywords: Traffic origin–destination matrices prediction, travel frequency, deep learning, gated recurrent unit, clustering

# A CITY-SCALE TRAFFIC DATASET FOR COMPREHENSIVE URBAN RESEARCH IN 10 UK CITIES

A. Xiangcheng LI [a], B. Xiaotong XU [a] and C. Wei MA [a*]
[a] *Department of Civil and Environmental Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
**Email: wei.w.ma@polyu.edu.hk (Corresponding author)*

City-scale traffic information on every segment of the road network is essential for urban planning and intelligent transportation systems as they assist in a comprehensive understanding of urban traffic characteristics. However, accessing such data on a city scale is challenging due to the limited number of sensors and privacy concerns. To address this issue, this research applies a data-driven approach based on the classic traffic assignment and then generates a unified traffic dataset. Specifically, the input data are sourced from open public datasets, involving the Office for National Statistics (ONS), OpenStreetMap, and Waze. By fusing different open-source datasets, this approach outputs comprehensive citywide traffic data on the entire road network. A total of 10 representative cities in the UK are selected as examples to showcase the effectiveness of this approach. The validation results indicate that the proposed approach for producing traffic assignment outcomes is reliable, which provides a new data-driven perspective for conventional traffic assignment.

Keywords: Road network; Traffic congestion; City-scale traffic dataset; Macroscopic traffic simulation; Traffic assignment

# DISTANCE-INFORMED NEURAL EIKONAL SOLVER FOR REACTIVE DYNAMIC USER-EQUILIBRIUM OF MACROSCOPIC CONTINUUM TRAFFIC FLOW MODEL

A. Yun YE [a*], B. Haoyang LIANG [b], C. Jian SUN [b] and D. Xiqun CHEN [c]
[a] *Faculty of Maritime and Transportation, Ningbo University, Ningbo, China*
[b] *College of Transportation Engineering, Tongji University, Shanghai, China*
[c] *College of Civil Engineering and Architecture, Zhejiang University, Hangzhou, China*
**Email: yeyun1@nbu.edu.cn*

This paper revisits the Reactive Dynamic User-Equilibrium (RDUE) model for dynamic traffic assignment (DTA) of macroscopic traffic flow in two-dimensional continuum space, focusing on the Eikonal equation—a crucial partial differential equation (PDE) with specific boundary conditions. Traditionally, solving Eikonal equations has relied on iterative numerical methods through the discretization of the continuum space. However, this discretization compromises the precision of numerical solutions and could lead to non-convergence issues during iterative processes. This study refers to Physics-Informed Neural Networks (PINNs) and develops the Distance-Informed Neural Eikonal Solver (NES-DI) for solving Reactive Dynamic User-Equilibrium models. While the previously proposed Neural Eikonal Solver (NES) performs badly in a strong heterogeneous cost field with large cost differences, NES-DI explicitly considers the influence of solid boundaries during the factorization process by incorporating distance information. In the numerical example, the DTA problem, which predicts the route choices in continuum urban areas, demonstrates that under the mesh size of 1001x1001, NES-DI achieves a reduction of over 62% in the relative mean absolute error compared to the first-order fast sweeping method and over 86% compared to NES. Furthermore, NES-DI addresses the discretization issue, facilitating predictions of solutions at arbitrary locations within the computation domain. The NES-DI shows the potential of solving RDUE problems with strong heterogeneity, which offers a promising alternative to discretization-reliant numerical methods.

Keywords: Macroscopic continuum traffic flow; reactive dynamic user-equilibrium; physics-informed neural networks; Eikonal equation; Dynamic traffic assignment

# INTEGRATING SPATIAL INSIGHTS WITH MACHINE LEARNING: ESTIMATING ANNUAL AVERAGE DAILY TRAFFIC BY VEHICLE TYPE ON LOCAL ROADS

A. Rami AL-SHUKAIRI [a], B. Liang MA [a,b*], C. Marc E.J. STETTLER [a.b]
and D. Daniel J. GRAHAM [a.b]
[a] *Department of Civil and Environmental Engineering,*
*Imperial College London, London, UK*
[b] *Centre for Transport Engineering and Modelling,*
**Email: liang.ma13@imperial.ac.uk (Corresponding author)*

Obtaining street-level annual average daily traffic (AADT) by vehicle type is necessary for various applications but still challenging, especially across large road networks. Despite recent advances in adapting machine learning (ML) algorithms to estimate AADT, the specific challenges of applying ML in spatial settings are typically overlooked. Our study proposes a methodology combining ML prediction, feature selection, and spatial considerations for effective AADT estimation. We differentiate AADT estimation into deterministic and stochastic components. A lightGBM model is used to predict the deterministic component of AADT in England and Wales at over 19,000 locations, incorporating over 900 spatial features with additional variables for spatial autocorrelation through local Moran's I index. To reduce redundant features from the high-dimensional feature set, LASSO is applied and has proven to effectively enhance model performance. The local Moran's I index is employed to assess the spatial autocorrelation of residuals, revealing areas where the model performs well and highlighting regions with significant spatial clustering that may require further refinement. Unlike traditional methods, we evaluate model performance using a cross-validation process designated for spatial models, consequently increasing the reliability of model assessment. The AADT estimates are further split by vehicle and fuel types, thereby supporting pollution emissions estimation and offering insights for sustainable development.

Keywords: Machine Learning; Spatial Prediction; Annual Average Daily Traffic; Feature Selection; High-dimensional Data.

As at December 7, 2024

# EVALUATION METHOD FOR VOIDS BENEATH AIRFIELD RIGID PAVEMENT SLABS BASED ON STRAIN SENSING

A. Zerui ZHAO [a*], B. Jianming LING [a], C. Fan YANG [a*], D. Jiake ZHANG [a] and E. Zhongxu GUO [b]

[a] *The Key Laboratory of Infrastructure Durability and Operation Safety in Airfield of CAAC (Civil Aviation Administration of China), Tongji University, Shanghai, China*

[b] *Shanghai Bayan Sensor Technology Co., Ltd., China*

[*] *Email: 2211226@tongji.edu.cn (Corresponding author)*

Voids beneath airfield rigid pavement slabs induce damages such as slab cracking and misalignment, which severely threaten the safety of aircraft operations. Traditional methods for measuring voids beneath airfield rigid pavement are affected by equipment accuracy, detection frequency, and testing efficiency, and that makes those methods can hardly evaluate the void properly. A full-scale test site with voids beneath the slab was constructed, and strain sensors were installed to establish the relationship between strain and the voids. Meanwhile, a finite element analysis model was developed using real input data from the full-scale test site to estimate the index parameters for evaluating voids beneath slabs based on strain values. Additionally, the optimal location for strain sensing was obtained based on the finite element analysis. Results revealed that strain perpendicular to runway centerline is more sensitive in detecting voids, and center of the transverse joint is the optimal location for strain sensing. Also, the difference between the maximum and minimum strain more accurately reflects the void compared to other parameters based on sensitivity analysis. The void evaluation index, referred to as 'R', was proposed in this work, with threshold values of 20%, 50%, and 80% representing different levels of void severity. Falling Weight Deflectometer (FWD) tests were conducted on the sides of slabs with voids at the full-scale site. The calculated R value, based on the measured strain data during the FWD testing, is 80.94%, indicating the presence of corner and edge voids.

Keywords: Airfield pavement, Voids beneath slabs, Strain sensing, Full-scale test site, Finite element method

# ANALYSIS OF REWARD PROGRAMS FOR LINER SHIPPING SERVICES

A. Tianfang MA [a], B. Xuecheng TIAN [a*], C. Yan LIU [a] and D. Shuaian WANG [a]
[a] *Department of Logistics and Maritime Studies, The Hong Kong Polytechnic University, Hong Kong*
**Email: xuecheng-simon.tian@connect.polyu.hk (Corresponding author)*

This study examines the effects of proprietary and coalition reward programs on pricing strategies and profitability in liner shipping services. Facing intense market competition, shipping companies implement reward programs to attract and retain customers, thereby increasing profits. Proprietary programs, designed by individual companies, and coalition programs, developed by alliances of companies, offer discounts to customers on repeat purchases. Through a series of computational experiments, this research evaluates how these two types of reward programs influence the profits of shipping firms. The analysis of proprietary reward programs demonstrates how a solitary liner shipping company can devise effective pricing strategies to outcompete peers not offering rewards, revealing a continuous increase in profits until reaching a critical discount rate threshold. In the component of this study examining coalition reward programs, a series of experiments are systematically designed to assess the variations in profitability between a single company not employing a reward program and two companies participating in a coalition reward program. The findings from these experiments indicate that both proprietary and coalition reward programs can significantly impact the market. Furthermore, reward programs may not consistently increase company profits; at times, they may reduce profits and intensify market competition.

Keywords: coalition reward program, proprietary reward program, liner shipping, maritime transportation

# TWO-STAGE DRONE DELIVERY NETWORK DESIGN WITH UNCERTAIN DEMAND

A. Wenjia ZENG [a*], B. Ruiwei JIANG [b], C. Hai YANG [a] and D. Hai WANG [c]

[a] *Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology, Hong Kong, China*

[b] *Department of Industrial and Operations Engineering, University of Michigan, Michigan, USA*

[c] *School of Computing and Information Systems, Singapore Management University, Singapore*

** Email: wzengag@connect.ust.hk (Corresponding author)*

Drones are expected to play an important role in the logistics and transportation sectors, with numerous nations and corporations already initiating pilot programs for the rapid delivery of goods, including fast food and groceries, using drones. There is a burgeoning interest in the potential for broader application of this drone delivery service. In light of this, this paper studies a drone delivery network design problem, particularly focusing on the urban low-altitude context. Our goal is to achieve a cost-effective solution that minimizes both the investment costs on network infrastructure and the subsequent operational costs. Specifically, this paper takes into consideration both the soft and hard time windows for customers and the capacity of drone parking and recharging facilities. To address the uncertainty of demand, we propose a two-stage distributionally robust optimization approach, which utilizes a distribution separation procedure and split cuts within the Benders decomposition algorithm. The validity and robustness of our proposed method are demonstrated through extensive experiments.

Keywords: drone delivery, urban low-altitude economy, network optimization, distributionally robust optimization, demand uncertainty

# A STUDY ON TRAVEL BEHAVIOR ANALYSIS OF CONTAINER SEMI-TRAILER TRUCK BY TRAVEL TYPE

A. Jinwon JANG [a*], B. Sangkyu LEE [a] and C. Dongjoo PARK [a*]
[a] *Department of Transportation Engineering, University of Seoul, Seoul, Korea*
**Email: jinwon.uos@gmail.com; djpark@uos.ac.kr (Corresponding author)*

As the scale and importance of container transportation as a logistics activity supporting global economic growth increases, various studies by transportation and logistics researchers are also actively being conducted. However, there is a lack of research distinguishing the three travel types occurring in inland container transportation (LTFC(Loaded Trailer with Full Container), LTEC(Loaded Trailer with Empty Container), ET(Empty Trailer)), and analyzing the characteristics of travel volume imbalance by type and its causes. This study utilized freight vehicle travel survey data conducted by the Korea Transport DB Center to construct travel data by type and analyze its characteristics. When dividing the daily trip-chain data of 1,654 vehicles into O/D units, the LTFC type accounted for 53.7%, LTEC 11.9%, and ET 34.4% of the total 3,878 trips/day. In terms of characteristics by type, LTFC trips were dominated by those from cities with major industrial complexes to Gangseo-gu, Busan where the Busan New Port is located; LTEC by Gangseo-gu, Busan to cities with major industrial complexes; and ET by internal trips within port cities. Major origins and destinations were clustered based on the weight of travel types, and their characteristics and causes were examined. Results are expected to be utilized in research or national policies for reducing ET type travel of container vehicles and alleviating container supply-demand imbalances.

Keywords: Travel Behavior, Container Transportation, Semi-Trailer Truck; Social Network Analysis

# BLOCKCHAIN-BASED CROSS-BORDER LOGISTICS PLATFORM OPERATIONS: A GAME-THEORETIC ANALYSIS

A. Qilong LI [a] and B. Haohan XIAO [a*]
[a] *School of Intelligent Systems Science and Engineering Jinan University (Zhuhai Campus)*
**Email: hhxiao@jnu.edu.cn (Corresponding author)*

With the booming of cross-border e-commerce, cross-border logistics platform operations have gained much attention recently. It integrates domestic and international logistics services with app-based platform technologies, which largely ease cross-border logistics for customers. Despite its merits in providing one-stop services for customers, cross-border logistics services are hindered by uncertainties due to several reasons such as the lack of reliable and effective traceability technology between participants. To identify the impact of blockchain on cross-border logistics platform operations, we adopt a game-theoretical approach to formulate the models with and without blockchain. Equilibrium results can be derived from the two models. Results show that the adoption of blockchain will positively affect the cross-border logistics platform but negatively affect carriers and customers when the cost of blockchain adoption is too large. Managerial implications concerning adopting the blockchain in cross-border logistics services are proposed at last.

Keywords: Blockchain; Cross-border logistics; Game-theoretic analysis; Traceability

# UNVEILING HETEROGENEITY OF URBAN GOODS VEHICLES' ROUTE CHOICE BEHAVIOR: ANALYSIS USING GPS DATA FROM THE TOKYO METROPOLITAN AREA

A. Yumi HAZENOKI [a], B. Takanori SAKAI [b*], C. Hideki OKA [c]
and D. Tetsuro HYODO [b]

[a] *Course of Maritime Technology and Logistics, Tokyo University of Marine Science and Technology, Tokyo, Japan,*

[b] *Department of Logistics and Information Engineering, Tokyo University of Marine Science and Technology, Tokyo, Japan*

[c] *The Institute of Behavioral Sciences, 2-9, Ichigayahonmura-cho, Shinjuku-ku, Tokyo, Japan*

**Email: tsakai2@kaiyodai.ac.jp (Corresponding author)*

Vehicle route choice models are used in transportation simulations and are important for evaluating policy impacts. For accurate policy evaluations, it is critical to properly replicate the sensitivities of route choices of vehicles on network performances. The characteristics of urban goods vehicle movements are heterogeneous and vary depending on vehicle type and operational purpose. However, past research on goods vehicle route choice analysis does not look into such heterogeneity in detail and provides limited knowledge about the route choice behaviors of urban goods vehicles. To fill this research gap, using GPS data with a large sample size collected by the Government of Japan, we develop route choice models for goods vehicles operated in the Tokyo Metropolitan Area, considering the combinations of vehicle size and trip destination characteristics. We estimate a path-size logit model and use a BFS-LE Algorithm for routes generation. The results indicate that the sensitivity to network performance varies widely by vehicle type. Light good vehicles (LGV) and Heavy goods vehicles (HGV) trips heading toward industrial area show relatively high sensitivity to travel cost. Furthermore, LGVs are most sensitive to time and cost in industrial areas. Moreover, results indicate that the value of time varies depending on the destination.

Keywords: truck route choice; urban freight; GPS; freight transport modeling; land use

# CANDIDATE FORWARD WAREHOUSES LOCATIONS FOR THE LAST MILE FRESH PRODUCT DELIVERY

A. Rongjie SUN [a], B. Zuoning JIA [a], C. Kun AN [a*] and D. Shadi SHARIF AZADEH [b]

[a] *The Key Laboratory of Road and Traffic Engineering of Ministry of Education, Tongji University, China*

[b] *Sustainable Urban Multi-modal Mobility Lab, Delft University of Technology, Netherlands*

[*] *Email: kunan@tongji.edu.cn (Corresponding author)*

E-commerce expansion has promoted the development of various warehousing and distribution models, including forward warehouses, which greatly improve the last mile delivery efficiency but pose challenges in their strategic layout. This paper introduces a methodology for identifying potential sites for forward warehouses specifically tailored for fresh product delivery. The approach comprises a two-stage process involving an Improved Fuzzy C-means clustering followed by the Hesitant Fuzzy TOPSIS method. The utilization of fuzzy clustering enhances precision, while incorporating hesitant fuzzy sets and employing the maximum deviation method serves to minimize subjectivity and overcome inherent limitations associated with handling discrete data. Subsequently, the proposed methodology is applied to a real-world case study in Shanghai. The final result is a candidate point set consisting of the top five optimal points selected from each cluster, which shows promising outcomes in terms of solution quality and computational efficiency when contrasted with traditional multiple criteria decision-making techniques. Moreover, the two-stage methodology offers significant computational cost savings by directly pinpointing optimal locations for forward warehouses rather than initially identifying a pool of candidate sites. Furthermore, this approach effectively quantifies the fuzziness of language and aligns with the unique characteristics of location selection problems.

Keywords: Forward warehouses, Candidate locations, Fresh product delivery, Improved Fuzzy C-means clustering, Hesitant Fuzzy TOPSIS

# INTEGRATING EXCESS DEMAND INSIGHTS INTO SOUTH KOREA'S RAIL NETWORK PLANNING

A. Heejo KIM [a], B. Hyungkeun SON [a] and C. Dongjoo PARK [a*]

[a] *Department of Transportation Engineering, University of Seoul, Seoul, Korea*

**Email: djpark@uos.ac.kr (Corresponding author)*

Intercity rail plays a critical role in South Korea's transportation network, offering a sustainable alternative to congested highways. However, the rail system faces significant congestion, particularly on weekends, when demand exceeds the available capacity. This study investigates the extent of excess demand for rail services by employing two methodologies: analyzing reservation waitlist data and examining weekday-weekend mode share differences. The first method utilizes waitlist data from South Korea's two major high-speed rail operators to estimate excess demand by calculating the proportion of waitlist cancellations due to seat allocation failures. The second method assesses excess demand by comparing changes in mode share between weekdays and weekends. The findings reveal that excess demand is notably higher on weekends, particularly in the Seoul metropolitan area, where capacity constraints are most pronounced. The study suggests that the current rail Origin-Destination (O/D) data, based on ridership, may underestimate actual demand by approximately 3%. The results underscore the importance of accounting for excess demand in transportation planning and demand forecasting, particularly in scenarios involving infrastructure investments and service expansions.

Keywords: intercity rail, excess demand, transportation planning, reservation waitlist, mode share

# RISKY BEHAVIOR ANALYSIS FOR CROSS-BORDER DRIVERS: A LOGIT MODEL AND QUALITATIVE COMPARATIVE ANALYSIS OF ODDS OF FAULT AND INJURY VULNERABILITY IN GUANGDONG, HONG KONG AND MACAU

A. Guangnan ZHANG [a], B. Qiaoting ZHONG [b*], C. Ying TAN [c] and D. Qingxuan YANG [a]

[a] *Institute of Guangdong, Hong Kong and Macao Development Studies, Sun Yat-sen University, Guangzhou, China*

[b] *Institute of Information, Guangdong Academy of Sciences, Guangzhou, China; Science and Technology Library of Guangdong, Guangzhou, China*

[c] *Guangdong University of Finance, Guangzhou, China*

**Email: i.qt.zhong@gmail.com (Corresponding author)*

Due to globalization and the acceleration of cross-border exchanges, cross-border risk behaviors have received widespread attention. Previous research has concluded that foreign cross-border drivers engage in relatively more risk-taking behavior patterns and are likely to experience a higher crash rate or be more inclined to cause severe crashes. However, there is little evidence on the comparison of drivers who belong to the same ethnic group driving across within-country borders. Based on the cross-border motor-vehicle crash reports from the Road Traffic Accident Database of the China Ministry of Public Security, this paper examines the risk factors of being at fault and getting killed or seriously injured in cross-border traffic crashes and casual paths toward crash liability and injury severity for Hong Kong and Macao drivers driving in the Chinese mainland. Factors such as gender, age, illumination, and weather conditions do not individually affect the risk of driver at-fault crashes or severe casualties in the crashes among Hong Kong and Macao drivers driving in the Chinese mainland. Nonetheless, collectively, these factors influence them along with different vehicle types, roads, and environmental factors. The conclusions of this research are valuable as representative references for crossborder risk management policies.

Keywords: cross-border risk behavior; cross-border driving; one country two systems; risk factors; causal paths

# PERFORMANCE EVALUATION SCOPE: COMPARING ROUTE BASED AND REGION BASED EVALUATION IN PUBLIC TRANSPORT

A. Chiang FU [a], B. Chia-Jung YEH [b*], C. Xin WANG [c] and D. Yu-Cheng TING [d]

[a] *Department of Transportation and Communication Management Science, National Cheng Kung University, Taiwan*

[b] *Department of Transportation and Logistics Management, National Yang Ming Chiao Tung University, Taiwan*

[c] *Hsinchu County American School, Taiwan*

[d] *International Bilingual School at Hsinchu-Science-Park, Taiwan.*

**Email: robert1328.mg10@nycu.edu.tw (Corresponding author)*

Performance evaluation is critical in public transport. However, it is not always easy to determine a suitable evaluation scope. For buses, route based performance evaluation is the common way to measure efficiency. However, routes tend to operate in different administrative regions. Sometimes, region based evaluation is needed for policy goals. To identify a suitable evaluation scope, this study uses a context dependent data envelopment analysis (CD-DEA) approach to measure performance efficiency with subsidised city buses in New Taipei City, Taiwan as the case study. There are 104 routes and 24 regions in New Taipei City. Two CD-DEA models are developed: route based and region based. In the route based model, the 104 routes are grouped into 20 efficiency levels. In the regional model, the 24 regions are grouped into three efficiency levels. The route based model can provide more improvement insights but does not easily provide aggregated regional level suggestions. While the two model results are quite different, the overall trends are similar. For the regions with the most city bus routes that are subsidised, they are both assessed at efficiency level 2, the mid level, in the region based model. In the route based model, most routes of these regions are ranked at efficiency levels 6 to 9 which are also in the mid range of the 20 efficiency levels. In the other words, the route based model and the regional model complement each other. This study concludes by proposing useful policy implications on how to use both model results to improve regional public transport performance.

Keywords: Performance Evaluation, Public Transport, Context Dependent Data Envelopment Analysis, DEA, Scope, Route Based Performance Evaluation, Region Based Performance Evaluation

**TRANSPOR TATION MODELING TO UNDERSTAND MOBILITY NEEDS IN RURAL AREAS**

A. Prof. Dr.-Ing. Lutz GASPERS[a*], B. Dennis DREHER, M.Eng[a], C. Leo CASEY, M.Eng.[a]
and D. Hannah WALTER, M.Eng.[a]
[a] *University of Applied Sciences Stuttgart, Germany,*
*Competence Centre for Mobility and Transport*
**Email: lutz.gaspers@hft-stuttgart.de (Corresponding author)*

Rural areas face unique challenges in addressing mobility needs due to lower population densities, limited public transportation options, and greater distances between destinations. To better understand and address these needs, a comprehensive traffic model has been developed. This model aims to capture the specific mobility patterns and requirements of rural populations, thereby providing a foundation for targeted solutions that support the transition to sustainable transportation systems. The research investigates the effectiveness of various interventions, such as the enhancement of public transport networks, the integration of shared mobility services, and the promotion of active transportation modes like cycling and walking. Additionally, the model evaluates the potential impacts of emerging technologies, including autonomous vehicles and electric mobility, on rural transportation dynamics. Preliminary results suggest that tailored solutions, which consider the distinct characteristics of rural areas, can significantly contribute to the broader goals of the transportation transition. Enhancing connectivity and accessibility through innovative and context-sensitive measures not only improves the quality of life for rural residents but also aligns with environmental and economic sustainability objectives. This study underscores the importance of developing adaptive traffic models that reflect the diverse needs of different regions. By providing insights into effective strategies for rural mobility, the research offers valuable contributions to policy-making and the implementation of sustainable transportation solutions in less urbanized areas. Ultimately, the findings highlight the role of rural regions in achieving a comprehensive and inclusive transportation transformation.

Keywords: Traffic model, suburban areas, shared mobility, mobility behavior

# A FLEXIBLE MULTI-SET STRATEGY FOR CROSS-LINE ROUTING OPERATING IN URBAN RAIL TRANSIT TO ADDRESS HIGH-DENSITY, SHORT-TERM TRANSFER PASSENGER DEMAND

A. Xin GUO [a*], B. Zhenbin ZHANG [a], C. Jin ZHOU [b] and D. Huijun SUN [a]

[a] *School of Systems Science, Beijing Jiaotong University, Beijing 100044, China*

[b] *Transportation and Economics Research Institute, China Academy of Railway Sciences Corporation Limited, Beijing, 100044, China*

[*] *Email: guoxin@bjtu.edu.cn (Corresponding author)*

Under urban rail transit network operations, significant disparities in passenger demand between lines can lead to resource wastage. Moreover, high transfer passenger demand increases the pressure on operational lines, transfer corridors, and network electricity usage, further exacerbating the temporal and spatial distribution differences in network passenger demand. Therefore, this paper proposes a multi-objective optimization model to minimize operating costs, passenger travel costs, and train energy consumption costs for new cross-line operations. This model employs a cross-line routing strategy to address high transfer demand issues between lines and a multi-set train operating strategy to tackle large temporal and spatial distribution differences in passenger demand between lines, ultimately optimizing train schedules across different lines in a coordinated manner. Additionally, the paper introduces an INSGA-II (Improved Non-dominated Sorting Genetic Algorithm) and validates the model using empirical data from Beijing's Metro Line 9 and Fangshan Line. The results indicate that this combined optimization scheme can reduce operating costs by 2.6%, passenger travel costs by 2.06%, and train energy consumption costs by 13.07%, while being compared to traditional single-line operations. Sensitivity analysis reveals that cross-line operations achieve better optimization effects when transfer passenger flow exceeds the threshold, transfer walking time exceeds the threshold, and non-transfer passenger demand does not exceed the threshold. This study contributes to the shared use of line resources in networked rail transit operations, improvement in the temporal and spatial distribution differences of passenger demand, and enhancement of system service quality, ultimately providing an effective reference for cross-line operations in urban rail transit.

Keywords: Urban rail transit network, cross-line operation, multiple-objective optimized model, INSGA-II Algorithm

POSTER SESSION 6

**A PREDICT-DECOMPOSE ALGORITHM FOR ON-DEMAND DYNAMIC RIDE-POOLING PROBLEM CONSIDERING ORDER CANCELLATIONS**

A. Jiguang WANG [a*], B. Xinglu LIU [a] and C. Jintao KE [a*]
[a] *Department of Civil Engineering, The University of Hong Kong, China*
**Email: jgwang@connect.hku.hk; kejintao@hku.hk (Corresponding author)*

On-demand ride-pooling services can enhance vehicle utilization by allowing drivers to transport multiple passengers per trip. However, their widespread adoption has been impeded by low user acceptance and frequent order cancellations, partly due to the uncertainty of passengers' behaviors in their willingness to accept trip fare and maximum endurable waiting time further complicates the design of pricing, routing and matching strategies. This study investigates a joint optimization problem for dynamic ride-pooling problems that consider two-stage uncertain order cancellations to maximize their overall expected revenue. We develop attractive fare discounts that offset the extra waiting times caused by shared rides and efficiently assign vehicles to pick up and deliver multiple passengers and new trip requests are promptly responded. For dealing with a large case in stochastic scenarios, a learning-based decomposition framework is proposed to swiftly solve high-quality feasible solutions for the MICQCP model. Extensive experiments have demonstrated that the gap between the solution obtained by the proposed approach within one minute and the solution obtained by the state-of-the-art solver in one hour is less than 3.5% but with a computational speed increase of more than 224 times in some cases. Furthermore, as the scale increases, the proposed approach will yield better solutions compared to the solvers. The numerical results suggest that incorporating joint optimization considering two-stage order cancellations can lead to a significant increase in the system's profit, approximately more than 10%, compared to not accounting for the order cancellation behavior.

Keywords: dynamic ride-sharing, shared mobility, pricing, order cancellation

# A BI-LEVEL REINFORCEMENT LEARNING METHOD FOR CUSTOMIZED BUS PLANNING CONSIDERING DYNAMIC PASSENGER INTERACTIONS

A. Zinuo CAO [a], B. Wanshan LI [a*], C. Sujun SUN [a*] and D. Xin XIA [b]

[a] *School of Intelligent Systems Science and Engineering, Jinan University, Zhuhai, China*

[b] *Department of Industrial Engineering, Tsinghua University, Beijing, China*

**Email: liws23@jnu.edu.cn; sjsun@jnu.edu.cn (Corresponding authors)*

Customized bus (CB) has become increasingly popular for its flexibility and efficiency. However, the dynamics and uncertainty passenger demand, which may attribute to passenger interactions such as transfer and competition, have brought challenge to the CB planning problem for operators. To address these interactions, this paper proposes a novel bi-level multi-agent reinforcement learning method for the customized bus planning problem considering dynamic passenger interactions. In particular, one CB operator agent jointly optimizes the set of bus routes, number of buses, and bus fares to maximize its profit, while multiple origin-destination (O-D) agents response to the CB scheme and decide their travel plans to minimize their travel cost. An ant colony optimization embedded genetic algorithm is employed for the decision of CB routes and number of buses, and a proximal policy optimization algorithm is used to decide the fares under O-D demands. For the O-D agents, a parameter sharing multi-agent actor-critic algorithm with designate multi-attention mechanism and action mask is used. A numerical case is presented, showing that our proposed method can assists CB operators in adapting dynamic demands well.

Keywords: Multi-agent reinforcement learning, customized bus, bi-level programming, dynamic programming, passenger interactions

As at December 7, 2024

# PERSONALIZED FAIR MATCHING IN PEER-TO-PEER RIDESHARING PLATFORMS UNDER BROADCASTING MODE: A LLM-DRIVEN DRIVER APPROACH

A. Zijian SHEN [a*], B. Taijie CHEN [a*], C. Jiguang WANG [a*] and D. Jintao KE [a*]
[a] *Department of Civil Engineering, The University of Hong Kong, China*
**Email: shenzj@connect.hku.hk; jgwang@connect.hku.hk; ctj21@connect.hku.hk; kejintao@hku.hk*
*(Corresponding authors)*

Peer-to-peer ridesharing platforms under the broadcasting mode dynamically broadcast orders to each driver, while the acceptance of offers cannot be guaranteed due to drivers' heterogeneous preferences. To address this issue, we propose an advanced method, Peer-to-peer RAG-Augmented Fair Matching (PRAFM) that leverages a Large Language Model (LLM) and Retrieval-Augmented Generation (RAG) to predict drivers' preference scores for orders. Specifically, we utilize LLM to predict the preference score according to historical match data and real-time information for each order. Then these preference scores are fed into an Integer Programming (IP) model. This model constructs personalized order menus broadcasted to drivers, considering their preferences, characteristics, and drivers' average income. Validated in Manhattan, our method leads to more fair and efficient assignments for drivers in the platform, including increased platform revenue and balanced average income for drivers.

Keywords: Peer-to-peer ridesharing, Dynamic matching, Broadcasting, Retrieval-Augmented Generation, LLM-agent

# OPTIMIZATION OF MULTI-DISCOUNT FARE SETTINGS FOR PUBLIC TRANSIT CONSIDERING TRAVEL FREQUENCY DISTRIBUTION

A. R. CHEN [a], B. S. SUN [a*] and C. F. LIU [a]

[a] *School of Intelligent Systems Science and Engineering, Jinan University, Zhuhai, China*

[*] *Email: sjsun@jnu.edu.cn (Corresponding author)*

The demand for public transit is growing rapidly, bringing more profit potential and competition to transit operators. The fare structure, greatly affects the mode choice behavior of passengers, is one of the most important aspects of public transit services to achieve profitability. However, discount fare, known to be an effective means to achieve travel equity, is seldom considered as a profitable strategy in practice and in the literature. To address this gap, this paper proposes a multi-discount fare setting (i.e., fare price, discount and breakpoint) optimization model to maximize profit, where demand distributions of passengers with different travel frequencies within a study period is considered in the nested-logit model to detail passengers' mode choice and ticketing behavior. Based on numerical examples, it is demonstrated that use of multi-discount fare can actually enhance profitability. Comparison on three different preferential fare structures, i.e., period pass, discount fare (discount after reaching accumulated fare) and multi-discount fare (discount after reaching accumulated fare and discount per trip) is made. The results indicate that multi-discount fare performs best among the three fare structures in terms of both profitability and passenger attraction under various passenger travel frequency distributions.

Keywords: multi-discount fare, fare structure, public transit

# EXPLORING THE DYNAMIC EVOLUTION OF PASSENGER FLOW FLUCTUATIONS IN URBAN COMPLEX METRO NETWORKS

A. Yangyang MENG [a,b*], B. Xiaofei ZHAO [c] and C. Wei MA [b]
[a] *The Hong Kong Polytechnic University Shenzhen Research Institute, China*
[b] *Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, China*
[c] *Department of Computer Science, City University of Hong Kong, China*
**Email: yangyang.meng@polyu.edu.hk (Corresponding author)*

As an open, nonlinear, and real-time evolving complex system, the metro network requires further exploration of its micro-power law phenomena. In particular, the spatio-temporal evolution mechanism of passenger flow fluctuations in complex metro networks remains unclear. This study addresses this knowledge gap by examining the Shenzhen Metro Network (SZMN) using Automatic Fare Collection (AFC) big data. The research investigates the power law characteristics of passenger flow fluctuations at both network and station levels across various dimensions. It then analyzes the influencing factors of flow fluctuations based on fundamental principles of traffic fluctuation and elucidates the dynamic evolution mechanism of passenger flow fluctuations in the complex metro network. This study empirically demonstrates the applicability of fluctuation scaling from complex network theory to urban metro passenger flow networks. The findings provide theoretical support and scientific guidance for flow fluctuation control and the formulation of safety management policies in urban metro systems, thereby contributing to the sustainable and resilient development of complex metro network systems.

Keywords: Complex metro networks, Passenger flow fluctuations, Power law characteristics, Dynamics evolution

# OPTIMAL OPERATING STRATEGY OF THE RIDE-SOURCING COMPANY UNDER MARKET AGGREGATION

A. Xin ZHANG [a,b] and B. Gege JIANG [a,b*]
*[a] Shenzhen Campus of Sun Yat-Sen University, Shenzhen, Guangdong, China*
*[b] Guangdong Provincial Key Laboratory of Intelligent Transportation System, School of Intelligent Systems Engineering, Sun Yat-Sen University, Guangzhou, Guangdong, China*
**Email: jianggg@mail.sysu.edu.cn (Corresponding author)*

The rapid development of ride-sourcing aggregation platforms in recent years has brought opportunities and challenges to ride-sourcing companies. The ride-sourcing companies can choose whether to join the aggregation platform. Under market aggregation, there are three feasible operating modes for ride-sourcing companies: self-management only, mixed mode, and aggregation only. In this paper, we use the market with a ride-sourcing company and an aggregation platform as examples to investigate the company's optimal operating strategy. This paper models the market equilibrium under company revenue maximization for three different operating strategies adopted by the company, respectively, and compares the optimal revenues under the three strategies. The model takes into account travelers with heterogeneous perceptions of the regulatory level as well as differences between the aggregation platform and the company in terms of pricing strategy, regulatory level, and vehicle fleet size. Numerical experiments show that when travelers choose all companies on the aggregation platform, the smaller companies are more motivated to join the aggregation platform. And the mixed mode is optimal in most cases, except when the company's vehicle fleet size is much larger than the aggregation platform. The results of this paper provide references for the operating strategy of ride-sourcing companies under market aggregation.

Keywords: Ride-sourcing; Market aggregation; operation strategy; Heterogeneous travelers

# ANALYSIS OF CASCADING FAILURE IN URBAN METRO NETWORKS: A DYNAMIC PERSPECTIVE INCORPORATING CHANGES IN TRAVEL DECISIONS

A. Huiying LEI [a], B. Xuedong HUA [a*], C. Weijie YU [a], D. Yongtao ZHENG [a] and E. Wei WANG [a]
[a] *School of Transportation, Southeast University, Nanjing, China*
[*] *Email: huaxuedong@seu.edu.cn (Corresponding author)*

Accidents in urban subway networks have significant impacts on urban transportation, yet most studies employ static methodologies, assuming constant network topology and travel plans. However, changes in subway passenger flow can influence network resilience, and the dynamic effects of post-accident traffic fluctuations on transportation demand are underexplored. Existing cascading failure models often overlook realistic scenarios where passenger overflow from station closures leads to network failures. To bridge this gap, this study meticulously defines the research scenario, demarcates potential post-accident travel decisions, and analyzes the multifaceted factors influencing cascading failures in urban subway networks. Specifically, the proposed cascading failure model takes into consideration both the static characteristics of network topology and the fluctuations in passenger volume, along with their interplay. Additionally, in assessing station importance and quantifying network resilience, multiple travel decisions under different durations are duly considered. The study's validation is conducted within the urban subway network of Nanjing, China. The findings suggest that accidents and fault stations of varied durations exert disparate impacts on passenger travel decisions, thereby influencing subway resilience. Notably, stations with integrated functionalities may hold more significant roles than those with singular functions. Furthermore, our results indicate a V-shaped effect concerning event duration— as the duration increases, the proportion of passengers cancelling subway travel rises, thereby enhancing the likelihood of stabilizing the subway network. This study provides a dynamic understanding of event impacts on subway networks, offering insights for optimizing event response strategies.

Keywords: Subway Network, Operational Incidents, Individual Travel Decision, Cascading Failure Model

# JOINT OPTIMIZATION OF SCHEDULING AND PASSENGER MATCHING FOR MULTI-ROUTE CONVENTIONAL AND FLEXIBLE INTEGRATED BUS SERVICES

A. Xinyan ZHANG [a], B. Jia GAO [b], C. Yushi PAN [b] and D. Kun AN [a*]
[a] *The Key Laboratory of Road and Traffic Engineering of the Ministry of Education, Tongji University, China*
[b] *Shanghai Urban Construction Design & Research Institute (Group) Co., Ltd, China*
[*] *Email: kunan@tongji.edu.cn (Corresponding author)*

In a conventional bus network, passengers have to transfer between different routes with long transfer time if direct service is not available. On the country, flexible buses can provide passengers with transfer-free services by going directly from their departure stops to destination stops. This study incorporates the flexible bus service to the conventional bus network to reduce the passengers' transfer time. Further, considering that there are special populations such as the elderly and disabled who lack the ability to utilize smart devices for submitting travel requests., we divide the passengers into two categories: special passengers and general passengers. This study proposes a mixed integer linear programming model for cooperative scheduling and passenger matching optimization of conventional buses and flexible buses, with the objective of minimizing the total system cost. The proposed model includes two stages. In the first stage, conventional bus timetables are optimized based on the historical dispatching data. In the second stage, special populations are assigned to conventional buses. The flexible buses' timetables and passenger-bus matching are optimized to respond to general populations' reserved requests and real-time requests. A Lagrangian relaxation algorithm and a cross-entropy algorithm are proposed to enhance computational efficiency of this large-scale problem. Sensitivity analysis is performed on key factors such as the transfer passengers' ratio, special passengers' ratio, and reservation time window. The results show that this integrated service outperforms the two separate modes that can efficiently serve all passenger types.

Keywords: Joint optimization, Conventional bus scheduling, Flexible bus scheduling, Passenger matching, Lagrangian relaxation algorithm, Cross-entropy algorithm

# OPTIMAL SUBSIDY SCHEME DESIGN FOR CONSTRUCTION AND DEMOLITION WASTE RECYCLING

A. L. YU [a], B. Q. GE [a] and C. K. HAN [a*]

[a] *School of Transportation and Logistic, Southwest Jiaotong University, Chengdu, China*

**Email: kehan@my.swjtu.edu.cn (Corresponding author)*

More than 10 billion tons of construction and demolition waste (CW) are generated globally each year, posing a significant challenge for disposal worldwide. Contractors, as the direct producers and handlers of CW, prioritize economic benefits, whereas the government, acting as the regulator, emphasizes environmental benefits and frequently influences contractor behavior by adjusting CW treatment fees. The misalignment in the leader-follower dynamic between the government and contractors significantly affects CW management. This study examines two types of Construction Waste Hauling Trucks (CWHTs)—new energy and diesel CWHTs—and employs a time-space network to model their movements. First, we develop a minimum-cost maximum-flow model aimed at maximizing contractor revenue. Subsequently, for the local government, we construct a bi-level optimization model based on the Stackelberg game, with the objective of minimizing pollution by appropriately reducing CW treatment fees (i.e., providing subsidies). The contractor's model is solved using a solver, whereas the bi-level model presents a greater challenge. Therefore, a hybrid heuristic method based on multi-objective particle swarm optimization is designed to address this challenge. In a large-scale case study conducted in Chengdu, the results demonstrate that the contractor's model achieves a near-optimal solution (gap=0.43%) within a short time (58 seconds), and the hybrid method effectively solves the bi-level optimization model (gap=1.51%) within a reasonable time frame (3.76 hours). The case study results indicate that appropriate government subsidies can lead to a 29.49% reduction in pollution.

Keywords: Bi-level optimization; Hybrid algorithms; Construction and demolition waste recycling; Pricing problem; Time-space network

## POSTER SESSION 7

# INTEGRATED OPTIMIZATION OF RAILWAY CAPACITY ALLOCATION AND PRICING FOR HIGH-SPEED RAIL EXPRESS DELIVERY CONSIDERING UNCERTAIN DEMAND AND UNCERTAIN CAPACITY

A. Mengrong YAN [a], B. Guangming XU [a*] and C. Linhuan ZHONG [a]
[a] *School of Traffic and Transportation Engineering,*
*Central South University, Changsha, Hunan, 410075, China*
[*] *Email: xuguangming@csu.edu.cn (Corresponding author)*

High-speed railway express delivery (HSReD) has become a new trend in the development of railway express delivery. However, the randomness of HSReD demand and the uncertain capacity of passenger trains for HSReD due to passenger flow demand pose a significant challenge to daily operations. Furthermore, the freight rate flexibility directly impacts the demand for HSReD, thereby influencing the rationality of transport plan. This study thus investigates an integrated optimization problem of railway capacity allocation and pricing for HSReD considering uncertainties in HSReD demand and available train capacity under the passenger-freight mixed transportation mode, aiming to maximize the economic benefits of HSReD. This problem is first formulated as a two-stage stochastic nonlinear and nonconvex programming model. The first stage determines the optimal freight rate for each origin and destination (OD) pair. The second stage determines the optimal transportation capacity allocation plan and the actual transportation plan between each OD pair for each train under each realization of the uncertain HSReD demand and capacity. A tailored spatial branch-and-bound-and-with Benders decomposition and Lagrangian relaxation algorithm is then developed to obtain the global optimal solution of the model. Finally, a simple example is conducted to verify the performance and effectiveness of the proposed approaches.

Keywords: High-speed railway express delivery, railway capacity allocation, Pricing, Uncertain demand, Uncertain capacity

# THE IMPACT OF PANDEMIC WAVE ON WORK PATTERNS AND COMMUTING FREQUENCY: A RETROSPECTIVE SURVEY ANALYSIS OF COVID-19 DATA IN SHANGHAI

A. Meiping YUN [a], B. Yijia DONG [a] and C. Yue MA [b*]
[a] *Key Laboratory of Road and Traffic Engineering of the Ministry of Education,*
*Tongji University, Shanghai, China*
[b] *Department of Urban Management, Graduate School of Engineering,*
*Kyoto University, Japan*
[*] *Email: ma.yue.55t@st.kyoto-u.ac.jp (Corresponding author)*

Public health crises profoundly impact work activities and commuting behaviors. The multiple waves of COVID-19 outbreaks across cities worldwide have demonstrated that, people voluntarily or involuntarily adapt their work patterns, such as shifting to remote work, and adjust their commuting choices. This study investigates changes in commuting behaviors among urban residents during three pandemic wave stages: pre-wave, outbreak, and post-wave, focusing on work patterns, commuting frequency, and key influencing factors. A retrospective longitudinal survey was conducted in Shanghai after the first wave of COVID-19 outbreak, to collect information on respondents' work, commuting, pandemic-related, and socio-demographic characteristics. Descriptive analysis and statistical tests revealed a 35% increase in telecommuting and a 50% decrease in commuting trips during the outbreak, with near-normal levels post-wave. Multinomial Logit models identified key factors influencing commuting frequency, such as telecommuting, weekly working hours, and direct commutes to workplaces. Telecommuting increased commuting frequency pre-wave, decreased it during the outbreak, and continued to reduce it post-wave. Work intensity consistently increased commuting frequency, with the most significant impact pre-wave and the least during the outbreak. The findings provide insights for policymakers to better understand and enhance strategies in response to unforeseen public events, including potential future pandemics like Disease X.

Keywords: COVID-19, work pattern, commuting frequency, questionnaire survey, Multinomial Logit model

# A PLANNING MODEL FOR MULTI-TERMINAL ELECTRIC BUS SYSTEM

A. X. ZHAO [a], B. J. MA [a*] and C. W. GU [a]
[a] *Department of Electronic and Electrical Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*
[*] *Email: jie90.ma@polyu.edu.hk (Corresponding author)*

With increasing emphasis on environmental protection and energy efficiency, electric bus systems have become an important trend in urban transportation. This summary aims to introduce a planning model for electric bus systems based on sustainability and efficiency. The model aims to optimize the operation and management of the public transportation system, thereby improving its energy efficiency and environmental performance. The model considers multiple key factors, including but not limited to: bus route planning, charging facility layout, battery replacement strategy, energy source selection, and operational management strategy. By comprehensively applying these factors, the model aims to achieve comprehensive optimization of the public transportation system, including increased mileage, reduced charging time and frequency, lower operating costs, and reduced carbon emissions. The key advantage of this model lies in its comprehensiveness and flexibility. It not only takes into account current technologies and facilities, but also considers future technologies and market changes, providing strong support for long-term planning and operation of the public transportation system. In addition, the model emphasizes collaboration with communities and government agencies to ensure that the sustainability and environmental performance of the public transportation system are fully realized. In summary, this electric bus system planning model provides a powerful tool for optimizing urban public transportation systems, helping to achieve sustainable and efficient public transportation systems that provide better travel experiences for urban residents, while also contributing to the protection and sustainable development of the urban environment.

Keywords: Bus planning, Bus scheduling, Electric bus, public network modeling

As at December 7, 2024

# COMPREHENSIVE OPTIMIZATION FOR HIGH-SPEED RAILWAY PASSENGER TRAIN LINE PLANNING AND TICKET ALLOCATION UNDER RANDOM DEMAND

A. Guangming XU [a*], B. Ziqi ZHU [a], C. Linhuan ZHONG [a] and D. Yini XIAO [a]
[a] *Central South University, China*
[*] *Email: xuguangming@csu.edu.cn (Corresponding author)*

With the increasing competition among various transportation modes in the passenger transportation market, railway enterprises urgently need to achieve efficient and sustainable operation. However, due to factors such as emergencies and extreme weather, passenger travel demand presents high uncertainty, posing significant challenges to the operation organization of high-speed railway(HSR). To enhance the capability of the HSR passenger transportation system to cope with random demand, trains on standby are firstly introduced, a comprehensive optimization method for HSR passenger train line planning and ticket allocation is proposed under the operation mode combining fixed schedule trains and temporary additional trains. Firstly, discrete scenarios are used to characterize the uncertainty of passenger demand, with the objective of maximizing the expected total revenue of HSR passenger transportation. Constraints such as train stops, section capacity, station capacity, and train capacity are comprehensively considered to construct a two-stage stochastic programming model. Then, through some linearization techniques, the model is transformed into an equivalent integer linear programming model, which can be solve by commercial optimization software such as GUROBI and CPLEX, directly. Finally, numerical experiments are conducted for the Zhengzhou-Xi'an HSR to validate the effectiveness of the model. The results show that the model we construct is correct and effective. The impact of changes in passenger loss coefficients on the model is also analyzed, which helps to enhance the competitiveness and overall operational efficiency of HSR in the passenger transportation market.

Keywords: Random Passenger Demand, Line planning, Ticket allocation, Trains on standby

# TWO-STAGE STOCHASTIC OPTIMIZATION OF SEAT ALLOCATION AND FLEXIBLE COMPOSITION FOR HIGH-SPEED RAILWAY CONSIDERING THE UNCERTAINTY OF EPIDEMIC

A. Can LI [a], B. Guangming XU [a*] and C. Xinyi LIU [a]

[a] *School of Traffic and Transportation Engineering, Central South University, Changsha, Hunan, China*

[*] *Email: xuguangming@csu.edu.cn (Corresponding author)*

The outbreak of the global epidemic pandemic has brought new challenges to high-speed railway operations. To ensure the safety of passengers, this paper proposes the social distancing strategy. However, due to the random occurrence of the epidemic (i.e., the risk level of epidemic in an area may change in a few days), the risk level at different stations exhibit uncertainty, consequently leading to uncertain train capacity and uncertain passenger demand. In the context of the uncertainty of the epidemic, improving revenue while meeting passenger travel demand and safety has become increasingly important for railway operators. Therefore, this paper proposes a demand-oriented flexible composition and seat allocation strategy, that is, the number of component units of each train can be flexibly changed and the quantity of seats of each train can be allocated to adapt to the changes in passenger demand and train capacity. Specifically, a two-stage stochastic optimization model incorporating flexible train composition and seat allocation is presented, aiming to maximize the revenue of the railway operators. Then the model is transformed into an equivalent integer programming model and solved by GUROBI. The effectiveness of the model is validated through numerical experiments, including a small-scale case study and a real case study of the Zhengzhou East-Xi'an North high-speed railway line. The results demonstrate that the proposed approach significantly improves the revenue of railway operators under the uncertainty of epidemic conditions while ensuring passenger travel demand and safety, compared to current seat allocation methods.

Keywords: Global epidemic, High-speed railway, Flexible composition, Seat allocation, Social distancing, Two-Stage Stochastic Optimization

# A PASSENGER BEHAVIOR SIMULATION MODEL FOR METRO TRANSFER CORRIDOR CONSIDERING COMMERCIAL ATTRACTION

A. Liangji TANG [a], B. Fangsheng WANG [a] and C. Ling HONG [a*]
[a] *Department of Transportation Engineering, Tongji University, Shanghai, China*
**Email: ss980308@tongji.edu.cn (Corresponding author)*

The "commercial-transportation" integrated development mode in TOD metro stations not only improves the transportation network layout but also further enhances the vitality of commercial spaces. However, commercial attraction can easily alter passenger behavior patterns, affecting passage order and efficiency in service areas. This study quantifies passenger consuming behavior characteristics based on individual trajectories and establishes a simulation model considering commercial attraction. Firstly, it elaborates the characteristics of transfer and consuming behaviors in detail and compares the differences between the strong-purpose and weak-purpose consuming behaviors, also develops the dynamic transformation process of the "transfer-consumption-transfer" behavior. Secondly, the YOLO v5 and Deep Sort algorithms are introduced for passenger movement detection and tracking, and spatial movement preferences of passengers with different walking directions and demand levels are revealed based on their trajectories. Finally, the commercial impact area is delineated based on behavior characteristics, and commercial attraction force, marginal force, hesitant force are introduced to construct a simulation model driven by commercial consumption events. The authenticity and effectiveness of the simulation model are validated through behavioral trajectory analysis.

Keywords: TOD metro station, commercial attraction, consuming behavior, passenger trajectory analysis, social force model

# RECREATIONAL MARIJUANA LEGALISATION: HAS TRAFFIC SAFETY WORSENED IN THE US?

A. ANUPRIYA [a*] and B. Daniel J. GRAHAM [a]
[a] *Department of Civil and Environmental Engineering,*
*Imperial College London, South Kensington, London SW7 2AZ, UK.*
**Email: anupriya15@imperial.ac.uk (Corresponding author)*

In the United States, traffic fatalities involving drivers testing positive for marijuana have risen sharply since the legalisation of recreational marijuana in several states, thereby prompting the need to comprehend the impact of the policy change on road safety. While it is well known that marijuana can impair driving ability, whether the recreational use of marijuana has *caused* an increase in traffic fatalities remains a contentious issue due to the difficulty in developing accurate roadside tests for marijuana impairment. Additional challenges in quantifying this causal impact arise because (i) Simulations may not accurately replicate driver impairment and road conditions, (ii) Estimation based on observational data must adjust for (unobserved) confounding factors, requiring an innovative model to generate causal inference, and (iii) The dynamic, evolving nature of the process requires capturing temporal relationships. This paper makes a pivotal contribution to this ongoing debate by delivering a rigorous study design to understand the causal impact of recreational marijuana legalisation on traffic fatalities. A consistent but lagged pattern of increased traffic fatality rates across several states following the legalisation of recreational marijuana is found, where the lagged effect is primarily driven by the drug's retail availability. These findings disprove any prevailing conjectures that dismiss the link between recreational marijuana and fatal traffic crashes.

Keywords: recreational marijuana, public health and safety, traffic safety, fatal crashes

# ESTIMATING SOURCE OF TRAFFIC CONGESTION FROM VEHICLE TRAJECTORY DATA USING HIERARCHICAL BAYESIAN MODEL

A. Kazuma HAYASHI [a*] and B. Toru SEO [a*]
[a] *School of Environment and Society, Tokyo Institute of Technology, Japan*
**Email: hayashi.k.bi@m.titech.ac.jp; seo.t.aa.@m.titech.ac.jp (Corresponding authors)*

Traffic congestion is the result of complex interactions between vehicles. Therefore, understanding driving behavior is essential to understanding the mechanisms behind congestion. The fundamental diagram (FD), which describes the relationship between speed and spacing (or equivalently, flow and density), is crucial for understanding driving behavior and congestion. The FD typically depends on road and vehicle characteristics, such as road geometry and driver characteristics. However, it is not clear which factor is dominant under certain conditions, especially at complicated bottlenecks such as sags. This makes it difficult to model and alleviate traffic congestion. This study aims to identify the sources of congestion by estimating an accurate FD that distinguishes the effects of both vehicle and road characteristics. We propose a novel FD model based on a hierarchical Bayesian framework to capture the influence of these factors and their interactions. This model enables the estimation of a more accurate FD that accounts for the effects of both road and vehicle. We estimated the proposed model using actual vehicle trajectory dataset on highway. The results confirm that the model would represent the sources of congestion, including specific road features and specific vehicle types. For example, at a certain sag, most of the vehicles contribute to the capacity reduction, but the effects of few vehicles were significantly high.

Keywords: Traffic flow theory, car following model, traffic capacity, Hierarchical Bayesian model, Complete vehicle trajectory data

# STOCHASTIC LIGHTHILL-WHITHAM-RICHARDS TRAFFIC-FLOW MODEL FOR NONLINEAR SPEED-DENSITY RELATIONSHIP

A. Tianxiang FAN [a*], B. S.C. WONG [a], C. Zhiwen ZHANG [b] and D. Jie DU [c]

[a] *Department of Civil Engineering, The University of Hong Kong, Hong Kong SAR, China*

[b] *Department of Mathematics, The University of Hong Kong, Hong Kong SAR, China;*

[c] *School of Mathematical Sciences, East China Normal University, Shanghai, China; Shanghai Key Laboratory of PMMP, East China Normal University, Shanghai, China; Key Laboratory of MEA, Ministry of Education, China.*

**Email: fantx@connect.hku.hk (Corresponding author)*

Stochasticity is becoming increasingly essential in traffic flow research, given its notable influence in several applications, such as real-time traffic management. To consider stochasticity in macroscopic traffic flow modeling, this paper introduces a stochastic Lighthill–Whitham–Richards (SLWR) model, which not only captures equilibrium values in steady-state conditions but also describes stochastic variabilities. The SLWR model follows a conservation law, in which the free-flow speed is randomized to represent heterogeneities of drivers. To more accurately reflect real-life traffic patterns, a nonlinear speed–density relationship is considered. For addressing this highly nonlinear problem, a dynamically bi-orthogonal (DyBO) method is coupled with the Taylor series expansion technique. The results of a simulation experiment show that the SLWR model can effectively describe the evolution of stochastic dynamic traffic with a temporal bottleneck. Moreover, the DyBO solutions exhibit reasonable accuracy while significantly reducing computation costs compared with the Monte Carlo method.

Keywords: Stochastic traffic modeling; Stochastic LWR model; Stochastic free-flow speed; Nonlinear speed–density relationship; Dynamically bi-orthogonal method

**HYSTERESIS PHENOMENON IN TRAFFIC SAFETY ANALYSIS**

A. Peilin ZHAO [a], B. Yiik Diew WONG [a] and C. Feng ZHU [a*]
[a] *School of Civil and Environmental Engineering,Nanyang Technological University, Singapore*
[*] *Email: zhufeng@ntu.edu.sg (Corresponding author)*

The hysteresis phenomenon has been extensively studied within the domain of traffic flow analysis, emerging as a forefront area of research. However, the implications of hysteresis for traffic safety remain largely unexplored. This study marks the first to report the presence of the hysteresis phenomenon in traffic safety through real-world vehicle trajectories and subsequent simulations. The inverse Time-to-Collision (TTC^(-1)) is utilized as a pivotal safety indicator to examine the pattern of safety hysteresis. From real-world trajectory data, distinct hysteresis loops (a counterclockwise loop at the microscopic level and a clockwise loop at the macroscopic level) are prominently observed in stop-and-go traffic scenarios. To quantify the magnitude of safety hysteresis, we introduce a new metric termed Safety Hysteresis Intensity (HI). Simulations results reveal that higher rates of deceleration significantly intensify the HI, while acceleration demonstrates a minor effect. The insights from this study not only enhance our understanding of the hysteresis phenomenon in traffic safety but also may guide the development of traffic management policies to mitigate its impact.

Keywords: Traffic safety, Hysteresis intensity, Intelligent driver model, Time-to-collision

# ATTITUDES TOWARDS AND PREFERENCE OF ENERGY-SAVING DRIVING FEEDBACK FOR ELECTRIC BUS DRIVERS: RESULTS OF A STATED CHOICE EXPERIMENT

A. Sirui NAN [a*] and B. Tiezhu LI [b]
[a] *Xi'an University of Architecture and Technology, China*
[b] *Southeast University, China*
[*] *Email: necessary1994@163.com (Corresponding author)*

The Energy-saving Driving Feedback (ESDF) serves as a pivotal solution, empowering drivers to cultivate enduring energy-saving driving habits while concurrently reducing vehicle energy consumption. However, a precondition for the successful implementation and adoption of ESDF is public acceptance, particularly in electric buses (EBs) as urban transport arteries. This paper, therefore, aims to examine factors influencing drivers' intention to use the ESDF system based on the collected data. Specifically, a stated choice experiment about the EB drivers' acceptance and preference of ESDF was conducted. Then, the result of experiment are analyzed by a binary mixed logit model to estimate the effect of system attribute, monetary incentives, socio-demographics, and transportation-related characteristics on the decision of drivers' willingness. The estimations suggest a favorable inclination among the EB drivers toward adopting ESDF. The system attributes, particularly the variations in speed and energy consumption, and the type of ESDF exert a significant impact on its usability. The outcomes further demonstrate that haptic feedback, either on its own or when combined, is the most favored feedback type. Besides, the choice to utilize this feedback appears to be notably associated with socio-demographic characteristics and monetary incentives. The findings can be used as a valuable source of information for policymakers and system designers.

Keywords: energy-saving driving feedback, electric buses, acceptance, preference

# OPTIMISING LAST-MILE DELIVERY NETWORK: LOCKER-DRONE LOGISTICS SYSTEM DESIGN UNDER UNCERTAIN DEMAND

A. Yunxiang SHU [a], B. Zhongyi JIN [a], C. Chenliang ZHANG [a], D. Kam K.H. NG [a*]

[a] *Department of Aeronautical and Aviation Engineering, The Hong Kong Polytechnic University, Hung Hom, Hong Kong SAR, China*
**Email: kam.kh.ng@polyu.edu.hk (Corresponding author)*

With the rise of e-commerce, urban logistics systems are under mounting pressure due to increasing logistics demands. At the same time, online shopping has become the primary way people shop, resulting in frequent deliveries of small parcels to various locations. This trend has created challenges for traditional last-mile delivery methods, complicating the process and driving up costs. Recently, the drone-locker system has been researched for prompt and efficient delivery within the logistics chain, particularly in the last mile. To promote the adoption of this system, we intend to propose a mixed-integer linear program (MILP) named the Locker-Drone Logistics System Planning Problem (LDLSPP) that includes joint decisions at strategic and operational levels. At the strategic level, we focus on the locker layout and location decisions, drone deployment, and inventory quantity of multiple commodity parcels. At the operational level, we concentrate on the decision about drone scheduling and parcel distribution. In LDLSPP, different types of modules will be assembled in the locker. The total number of modules must not exceed the limit. The limits differ in lockers considering geographical space and manufacturing technology limitations. We also consider uncertain environmental factors in the logistics system, such as customer demand. To promote the efficiency of the logistics systems, the unsatisfied and unused penalties for different types of commodities are set. LDLSPP takes the minimum cost as an objective. An improved Benders Decomposition Algorithm is adopted to solve the LDLSPP. Finally, a numerical analysis is conducted to verify the effectiveness of LDLSPP.

Keywords: Urban air mobility, Multi-agent systems, Collision avoidance, Air traffic congestion, Route guidance

# MULTI-PERIOD BICYCLE NETWORK DESIGN USING GENETIC ALGORITHM

A. Chin Sum SHUI [a*] and B. Yuk CHAU [a]
[a] *Department of Transportation and Logistics Management,*
*National Yang Ming Chiao Tung University, Hsinchu City, Taiwan ROC*
**Email: csshui@nycu.edu.tw (Corresponding author)*

The rising popularity of bicycle-sharing systems as environmentally friendly and congestion-reducing means has raised awareness of the need for well-structured bicycle networks with isolated and continuous bikeways to motivate cycling. So, designing a bicycle network to maximize cycling demand becomes essential under the designated budget. This paper proposes a multi-period bicycle station and bikeway network design problem with demand elasticity, aiming to maximize all periods' demand coverage. The problem is formulated in terms of multiple periods because a bicycle network needs to be completed in multiple years while the construction budget is often allocated periodically. The proposed demand elasticity expresses the willingness to cycle as a function of bicycle station access times to bike stations and the total travel time. A genetic algorithm with a station-based elimination heuristic and tailor-made mutation operators is proposed to solve the problem by determining the subset of bicycle stations and bikeways that covers the largest total demand served within a given budget in periods. Numerical studies show that the proposed demand elasticity function can effectively reflect the effects of travel time and budget level on served demand. In the multi-period design, an earlier high investment can serve more demand. Moreover, when budgets in later periods allow the opening of new stations, these stations reduce the total travel time of OD pairs and serve more demand.

Keywords: bicycle network design; multi-period; demand elasticity; elimination heuristic; genetic algorithm

# CONSIDERING PATH ORDER AND PERCEPTUAL CORRELATIONS IN A TOLLED NETWORK WITH ORDERED GEV MODEL

A. Yu GU [a] and B. Anthony CHEN [a*]

[a] *Department of Civil and Environmental Engineering,*
*The Hong Kong Polytechnic University, Hong Kong SAR, China*

[*] *Email: anthony.chen@polyu.edu.hk (Corresponding author)*

While the growth of e-commerce has transformed rural logistics in fundamental ways, the application of electric cable cars in rural logistics remains underexplored. This study investigates the potentials of electric cable cars in reducing transport carbon emissions and enhancing rural sustainability through an in-depth study of detailed operations of an electric cable car system (with 22 logistics stations) in Anyuan County of Jiangxi Province over a period of 32 months from December 2020 to July 2023. This study employs a detailed carbon emission calculation methodology, considering factors such as characteristics of different transport vehicles, goods weight, and transport distance, to compare carbon emissions between a hybrid transport model electric cable cars and typical rural road transport modes of motorcycles and light trucks and a road-only transport model. More than 26,928 transactions, together with their product types, are analyzed. Results indicate that electric cable cars have significant emission reduction potential in rural logistics. The study also categorizes products in rural logistics as rural small business, consumer goods, and productivity-enhancing goods, and analyzes transaction characteristics and their impact on rural wellbeing across these categories. Findings indicate that e-commerce platforms promote diverse goods circulation in rural areas, positively affecting villagers' quality of life and economic income. The study is among the first to provide scientific evidence on the role of technological advances in supporting rural transport decarbonisation and wellbeing.

Keywords: path order correlation, ordered GEV model, path overlap, bi-objective user equilibrium, tolled network

# CONSTRUCTING A PUBLIC TRANSPORT SIMULATION BY FUSING OPEN SOURCE DATA INTO SUMO WITH KYOTO CASE STUDY

A. Andreas KELER [a*], Tomoki NISHIGAKI [b] and Jan-Dirk SCHMÖCKER [b]
[a] *JSPS International Research Fellow, Department of Urban Management, Kyoto University, Kyoto, Japan*
[b] *Department of Urban Management, Graduate School of Engineering, Kyoto University, Kyoto, Japan*
**Email: andreas.keler@mytum.de (Corresponding author)*

Despite the growing availability of public transport performance data, understanding the relationship between demand and supply remains time-consuming and data-intensive, especially in tourist-heavy urban areas where visiting dynamics at Points of Interest (POIs) play a crucial role. To tackle this, we propose a methodology using microsimulation of public transportation, leveraging open-source software SUMO and freely available geodata, to create a comprehensive digital representation of Kyoto's transit system. Recognizing potential data incompleteness in OpenStreetMap, we employ a data crawling approach to gather official data from local transport services. Our novel method automates the reconstruction of bus services, routes, schedules, and headways in Kyoto.

Validation of our simulation involves comparing it with recorded travel times and trajectories, primarily from passenger tracking experiments during bus trips. Initial findings reveal dependencies on vehicle type definitions and urban infrastructure detail, particularly focusing on Kyoto's circular bus routes. We aim to provide insights into the quality of our simulation after multiple processing steps.

Our objectives include introducing novel approaches for validating the simulation network and depicting realistic traffic flow under changing demand conditions. We discuss calibration experiments, define city-wide simulation scenarios, and address challenges arising from system complexity. We aim to enhance our understanding of transit dynamics in Kyoto's unique urban environment. Through this work, we hope to contribute to the advancement of microsimulation methodologies for public transportation analysis in complex urban settings.

Keywords: Public Transport Simulation, Data Fusion, Open Source Data, Microscopic Traffic Flow Simulation, Urban Digital Twin

# IMPROVING TRANSPORTATION NETWORK REDUNDANCY BY INTEGRATING LINK ADDITION AND LINK RETROFITTING

A. Kai QU [a,b], B. Xiangdong XU [b] and C. Anthony CHEN [a*]

[a] *Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Kowloon, Hong Kong, China*

[b] *Urban Mobility Institute, Tongji University, Shanghai, China*

* *Email: anthony.chen@polyu.edu.hk (Corresponding author)*

This research explores a new perspective of improving route redundancy through a strategic network improvement scheme that integrates existing link retrofitting and new link addition, which can ensure that ample routes are available to successfully and efficiently serve essential trips. A stochastic programming model is developed to identify the integrated scheme that minimizes the loss of network route redundancy under uncertain disruptions subject to the budget constraint. An approximation solution method is devised to transform the original difficult-to-solve model without an explicit objective function of loss of redundancy into a computationally tractable binary integer linear programming model. We test the methodology through numerical experiments on the Sioux-Falls network. Results show that the integrated scheme consistently outperforms schemes based solely on link addition or link retrofitting under different settings of construction costs, available budgets, and link disruption probabilities. Additionally, the presented algorithm efficiently solves the model while yielding high-quality solutions. The developed mathematical tool can support planners in designing resilience-oriented network improvement plans to promote the construction of resilient cities.

Keywords: Resilience; Optimization; Redundancy

# BUS LOCAL ROUTE OR COVERAGE ROUTE? BUS ROUTE CHOICE BEHAVIOR WITH LATENT CLASS MODEL

A. Barbara T.h. YEN [a*], B. Chia-jung YEH [a], C. Yu-chiun CHIOU [a] and D. Jin-yuan WANG [a]

[a] *Department of Transportation and Logistics Management, National Yang Ming Chiao Tung University, Taiwan*

[*] *Email: barbarathyen@nycu.edu.tw (Corresponding author)*

Bus is one of the main public transport modes in most cities. There are different types of bus routes, including coverage bus and local bus. Coverage bus route design can provide higher coverage to increase the accessibility of certain areas, but this route design might cause longer travel times and travel distances. As to the local bus, it is a more direct and express service serve on main corridors. Each route type might have its design purposes to meet certain policy goals (e.g., public transport coverage target). However, do those designs meet users needs? This study aims to investigate bus route choice behavior with the latent class model to understand how user heterogeneity might influence route choice results. This study uses one corridor with two bus routes (i.e., coverage bus and local bus) in Yilan County in Taiwan as the case study with smart card data applications. Model results show that there are four groups that can be identify. Some interesting results are found. For example, captive users (i.e., commuters) are found to be not sensitive to travel time and cost. This paper concludes with some spatial-based route improvement strategies based on user types.

Keywords: route choice, bus route design, public transport accessibility, latent class model

# PROMOTING GENDER-INCLUSIVE TRANSPORT AND ENHANCING MOBILITY OF WOMEN

A. N. ALI [a] and B. R.c.p. WONG [a*]
[a] *Department of Civil Engineering, The University of Hong Kong, Hong Kong*
[*] *Email: cpwryan@hku.hk (Corresponding author)*

In some developing countries, the mobility of women is commonly restricted by socio-cultural and religious beliefs. This limitation restricts their access to basic amenities such as healthcare and education. In this study, our aim is to promote gender-inclusive transport with a special focus on enhancing mobility of women. We have designed and conducted a questionnaire survey using the concepts of theory of planned behaviour and norm activation model, and we have used the collected data to develop a multivariate structural equation model. The findings indicate that attitudes, subjective norms, and personal norms are the significant predictor of social acceptance of women's mobility. Additionally, perceived behavioural control is a significant positive predictor that influences perceived transport policies. Based on these results, numerous transport policies are proposed in this study. We believe that the outcomes can provide valuable insights to transport planners and policy makers in promoting transport equity in developing countries.

Keywords: Gender-inclusive transport, Mobility of women, Theory of planned behavior, Norm activation model, Structural equation model

## POSTER SESSION 8

### WHAT CONTRIBUTES TO INDIVIDUAL'S '15-MINUTE CITY' TRAVEL BEHAVIOR? AN INVESTIGATION OF A NATIONAL TRAVEL SURVEY IN THE NETHERLANDS

A. Tanhua JIN [a,b*], B. Eric KOOMEN [a*]
[a] *School of Business and Economics, Vrije Universiteit Amsterdam, Netherlands*
[b] *Department of Geography, Ghent University, Belgium*
[c] *Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology, Hong Kong, China*
**Email: t.jin@vu.nl; e.koomen@vu.nl (Corresponding author)*

While the concept of a 15-minute city has been adopted by many cities globally, most research has primarily examined the potential accessibility of daily activity location rather than actual travel behavior. This study addresses this gap by analyzing a national travel survey to assess the extent to which residents in the Netherlands engage in 15-minute city lifestyles. Additionally, the study investigates how sociodemographic factors and the built environment influence the likelihood of 15-minute city travel behavior using structural equation modeling. Findings indicate that older adults, females, individuals with higher education, larger households, and those with greater disposable household income are more likely to engage in 15-minute trips. In contrast, employed individuals, those with a driving license or car, and those in households with children are less likely to do so. Furthermore, habitual travel behaviors significantly impact the likelihood of engaging in 15-minute city travel. Residents in denser, mixed-use areas with better public transportation and higher service density are less likely to be habitual car users, and thus more likely to adopt 15-minute city behaviors. Additionally, such residents tend to make less complex trip chains, further enhancing the likelihood of engaging in 15-minute travel. This research also found that the built environment at the residential neighborhood level plays a more important role in shaping individuals' '15-minute' travel behavior, compared to that at the level of trip origins and destinations. This study provides practical insights regarding land use interventions for policymakers aiming to implement the 15-minute city concept.

Keywords: 15-minute city; built environment, habitual travel behavior, structure equation modeling, Netherlands

# EXAMINING ELDERLY ACTIVITY IN SINGAPORE: THE ROLE OF PERCEIVED AND PHYSICAL ACCESSIBILITY

A. Wei ZHOU [a] and B. Ghim Ping ONG [a*]
[a] *Department of Civil and Environmental Engineering, National University of Singapore, Singapore 119077*
[*] *Email: ceeongr@nus.edu.sg (Corresponding author)*

As the worldwide elderly population continues to grow, understanding the impacts of both perceived and physical accessibility is essential for designing inclusive and sustainable cities and enhancing elderly engagement in outdoor activities. This study first conducted a questionnaire survey with 616 valid individuals aged 50 years and older in Singapore. Participants were asked to assess their subjective perceptions of local accessibility, including access to nearby facilities, the condition of walkways, and their sense of safety while walking, based on their daily experiences. Respondents also reported their weekly frequency of outdoor activity both before and during the COVID-19 pandemic. In parallel, geospatial data was collected to evaluate the physical accessibility on a spatial scale. By employing a series of ordinal logistic regression models with gradually added independent variables, the study analyzed the effects of both perceived and physical accessibility on elderly mobility. The results demonstrate that the impact of accessibility factors was more significant during the pandemic than before, underscoring the importance of understanding elderly patterns, especially during such crises. Furthermore, while certain aspects of perceived and physical accessibility, such as covered paths, consistently influenced elderly mobility, others, such as dedicated cycling paths, exhibited contrasting effects. These insights are valuable for researchers and urban planners aiming to create more inclusive and sustainable urban environments that cater to the mobility needs of aging populations.

Keywords: elderly mobility, perceived accessibility, physical accessibility, ordinal logistic regression

# A COPULA-BASED APPROACH FOR JOINTLY MODELING INJURY SEVERITIES OF DRIVERS AT VEHICLE LEVEL IN TRUCK-INVOLVED CRASHES

A. Penglin SONG [a*] and B. N.n. SZE [a*]

[a] *Department of Civil and Environmental Engineering,*

*The Hong Kong Polytechnic University, Hong Kong SAR, China*

[*] *Email: peng-lin.song@connect.polyu.hk; tony.nn.sze@polyu.edu.hk (Corresponding authors)*

Trucks, due to their size and weight, can cause more severe damage in collisions compared to smaller vehicles. Truck-involved crashes are associated with substantial property damage, serious injuries, and even fatalities. Conventional studies usually examine the most severe injury at the crash level or model the injury severity of truck and car drivers separately. However, in the same truck-involved two-vehicle crash, the severity of injuries suffered by the two drivers may be interrelated, and the factors influencing the injury severities on both sides may be different. In this study, injury severity of drivers in truck-involved two-vehicle crashes are jointly modeled using a copula-based multivariate approach by accounting for potential correlations due to common observed and unobserved factors. Crash data of truck-involved crashes in North Carolina in 2019 is used. Results indicate that there are considerable differences for the effects of factors on the likelihood of driver injury between truck and passenger vehicle. The proposed copula-based method is capable of capturing possible interrelation and has superior interpretation power. This study should shed light on developing effective countermeasures to improve road safety.

Keywords: Truck-involved crashes, Crash injury severity, Copula, Joint model

# ASSESSING THE IMPACT OF A CIRCLE LINE ON THE RESILIENCE OF THE SHANGHAI METRO NETWORK

A. Shicheng ZHAO [a] and B. Xiangdong XU [a*]
[a] *The Key Laboratory of Road and Traffic Engineering, Tongji University, Shanghai, China*
[*] *Email: xiangdongxu@tongji.edu.cn (Corresponding author)*

Resilience, as an indicator for assessing a system's ability to hedge against risk, has been of interest to many scholars and practitioners in the field of transportation in recent years. Particularly, redundancy and vulnerability are two important dimensions of resilience. Circle line is a special form of urban rail transit line that may reshape the connection of multiple lines in a large-scale metro network. Examining the impact of a new circle line on the resilience of a metro network can provide new insights into the role of circle lines, specifically whether a circle line enhances the resilience of a network. To this send, this study assesses the impact of the planned Line 26 (a circle line) on the resilience of the current Shanghai metro network, which is one of largest metro networks in terms of length and ridership. The impact of the circle line on network resilience is assessed by calculating changes in the redundancy and vulnerability of the Shanghai metro network due to the addition of the circle line. The results show that the circle line increases the level of network redundancy and improves its distribution, promoting the balance of the statistical and spatial distribution. Although the circle line reduces the overall network vulnerability, it also increases the vulnerability of many existing links and nodes. It is necessary to coordinate the planning of a new circle line and protection/enhancement of existing lines/stations.

Keywords: circle lines, resilience, redundancy, vulnerability, metro network

# CORRELATION BETWEEN THE BUILT ENVIRONMENT AND DOCKLESS BIKE-SHARING TRIPS CONNECTING TO URBAN STATIONS

A. Jiaomin WEI [a*], B. Zihan KAN [b], C. Mei-Po KWAN [c], D. Zhuo LIU [d],
E. Yanyan CHEN [d] and F. Yang WANG [d]

[a] *Department of Geography and Resource Management, The Chinese University of Hong Kong, Shatin, Hong Kong, China*

[b] *Department of Geography and Resource Management & Institute of Space and Earth Information Science, The Chinese University of Hong Kong, Shatin, Hong Kong, China*

[c] *Department of Geography and Resource Management & Institute of Space and Earth Information Science & Institute of Future Cities, The Chinese University of Hong Kong, Shatin, Hong Kong, China*

[d] *Beijing Key Laboratory of Traffic Engineering, Beijing University of Technology, China*

**Email: jiaominwei@link.cuhk.edu.hk (Corresponding author)*

The influence of the built environment on dockless bike-sharing (DBS) trips connecting to urban metro stations has always been a significant problem for planners. However, the evidence for correlations between microscale built-environment factors and DBS-metro transfer trips remains inconclusive. Therefore, taking Beijing as a case study, this study analyzes the correlation of built environment with DBS–metro transfer trips from the macroscopic and microscopic views. This study innovatively delineated the urban metro station influence scope for each metro station using the actual cycling distance of DBS trips connected to the station. The built-environment variables at macroscale and microscale were comprehensively extracted from multi-source data for the urban metro station influence scopes, in order to analyze their correlations with the trip density and cycling speed of DBS–metro transfer trips by a multiple linear regression model. Accordingly, 6 microscale built-environment factors are extracted from street-view images using deep learning and integrated into the analysis model, together with 14 macroscale built-environment factors and 8 potential influencing factors of socioeconomic attributes and metro station attributes. The results reveal the significant positive influence of greenery and presence of barriers on trip density and cycling speed. Additionally, presence of streetlights is found to be negatively correlated with both trip density and cycling speed. Presence of signals is also found to have an influence on DBS-metro transfer trips, but it only negatively impacts trip density. These findings have the potential to support the policy-making processes for relevant planning departments and operating companies.

Keywords: Bike sharing, built environment, metro station, street-view image, cycling speed

# EXPLORING THE CRASH EFFECTS OF ROADWAY ATTRIBUTES AND ELEMENTS ON ROADWAY SEGMENTS IN AN URBAN MIXED TRAFFIC ENVIRONMENT

A. Kun-feng (Ken) WU [a], B. Tong LIN [a*] and C. Po-jui CHEN [a]
[a] *Department of Transportation and Logistics Management,*
*National Chiao Tung University, Taiwan, ROC*
[*] *Email: atonton0131@gmail.com (Corresponding author)*

With the increasing use of powered-two-wheelers (PTWs) in many urban areas, especially in Asia, the number of PTW-related crashes, fatalities, and injuries are increasing. Today, PTW fatalities account for more than half of all road deaths in many Asian countries. It is perhaps surprising, therefore, that there has been only limited research done on which roadway attributes are influential to traffic safety in an urban mixed traffic environment where PTWs are predominant. As such, this study seeks to research into the effects of roadway attributes on traffic safety in an urban mixed traffic environment to shed light on traffic safety where PTWs are prevalent and where they share the same roads with cars, buses, and trucks. To better understand how traffic safety is associated with the roadway attributes, the investigation was conducted in terms of levels of crash severity, manner of collisions, and types of vehicles involved in a crash, as performance measures. As these crash types are correlated with each other on the same roadway segments, a multivariate Poisson log-normal model (MVPLN) is applied. A total of 164 divided roadway segments in Taipei City, Taiwan, from 2011 to 2016, are included in the analysis. It was found that the most influential roadway attributes on traffic safety include lane width, number of access points, presence of a bus stop, and the proportion of PTWs to total traffic volume.

Keywords: Powered-two-wheelers (PTWs), roadway elements, lane width, mixed traffic environment

# INVESTIGATING AND ENHANCING NON-METRO TRIPS AND LIFE BETWEEN STATIONS: INSIGHTS FROM HONG KONG

A. Yunting MIAO [a*] and B. Jiangping ZHOU [a]
[a] *Department of Urban Planning and Design,*
*The University of Hong Kong, Hong Kong SAR, China*
[*] *Email: ytmiao@connect.hku.hk (Corresponding author)*

Urban rail transport supports interconnected trip chains with different functions and purposes and has a significant role in high-density cities. Despite their importance, Non-Metro Trips (NMTs)—trips between station pairs within a specified distance—have been largely overlooked in both academic research and practical application. These NMTs contribute to Life between Stations (LbS), enhancing metro riders' satisfaction with trip chains, fostering community belonging, and improving overall quality of life. Utilizing smartcard data from Hong Kong across 12 weekends in 2019, this study examined the spatial distribution of LbS and applied K-Means clustering to classify station pairs into four distinct clusters. To explore the determinants of varying LbS patterns, a multinomial logistic regression model was used to evaluate the influence of built environment characteristics, with feature importance further corroborated by a Random Forest model. The analysis reveals that distance and population density play crucial roles in shaping LbS patterns, with residential areas and green spaces contributing to longer activity durations. Moreover, transport infrastructure, particularly station design, affects metro interactions, while newer urban development tends to decrease LbS frequency and duration. Each cluster exhibits unique dynamics driven by local features, such as pedestrian-friendly environments, administrative centers, and commercial hubs, offering valuable insights for optimizing urban planning and transit systems. Our findings thus shed light on built-environment related predictors of LbS and tailor-made countermeasures to improve LbS across rider groups.

Keywords: Non-Metro Trips, Life between Stations, Built environment, Explainable machine learning, Nonlinearity, Hong Kong

# A NOVEL METHOD FOR TRAFFIC STATE ESTIMATION IN UNMONITORED NETWORK LOCATIONS

A. Feng XIAO [a], B. Renbin PAN [b], C. LULI [a*], D. Hegui ZHANG [c] and E. Minyu SHEN [d]

[a] *Business School, Sichuan University, Chengdu 610064, China*

[b] *School of Business Administration, Southwestern University of Finance and Economics, Chengdu 611130, China*

[c] *School of Data Science and Artificial Intelligence, Dongbei University of Finance and Economics, Dalian 116025, China*

[d] *School of Management Science and Engineering, Southwestern University of Finance and Economics, China, Chengdu 611130, China*

[*] *Email: lliaw@connect.ust.hk (Corresponding author)*

Estimating data in locations without sensors is crucial for understanding traffic dynamics. Challenges include sparse sensor deployment, insufficient mobile sensor coverage, and unreliable sensor data. To address these, we frame the problem as a spatiotemporal kriging task and propose a novel graph transformer model, Kriformer. This model estimates data accurately at locations lacking sensors by mining complex spatial and temporal correlations, even with limited sensor resources. Kriformer leverages the transformer architecture to expand the model's perceptual range and solve edge information aggregation challenges, enabling the collection of spatiotemporal information from relevant locations. We constructed a positional encoding module that deeply embeds the spatiotemporal features of nodes, and designed a sophisticated spatiotemporal attention mechanism. The multi-head spatial interaction attention module captures subtle spatial relationships between observed and unobserved locations. During training, a random masking strategy forces the model to learn and optimize with partial information loss. The spatiotemporal embedding mechanism and multi-head attention mechanism work in synergy, guiding the model to capture spatiotemporal correlations comprehensively. Experimental results show that Kriformer excels in representation learning, particularly for unobserved locations, with extensive validation on two real-world traffic speed datasets demonstrating its effectiveness in spatiotemporal kriging tasks. This research provides a powerful tool for traffic managers to estimate traffic states and alleviate congestion, offering valuable insights for data estimation and prediction in other fields.

Keywords: Traffic speed, spatio-temporal data, kriging, transformer, graph neural network

# EFFECTS OF WEATHER CONDITIONS ON PEDESTRIAN CROSSING RISK PERCEPTION AT MIDBLOCK: A CAVE-BASED SIMULATOR STUDY

A. Manman ZHU [a*] and B. N.N. SZE [a*]

[a] *Department of Civil and Environmental Engineering,*

*The Hong Kong Polytechnic University, Hung Hom, Hong Kong*

[*] *Email: man-man.zhu@connect.polyu.hk ; tony.nn.sze@polyu.edu.hk (Corresponding author)*

Pedestrians are considered a vulnerable road user group due to their lack of physical protection compared to motorized vehicle occupants. Weather conditions significantly affect road traffic safety and impact all road users. Adverse weather conditions, ranging from light rain to dense fog, affect visibility, driving behavior, traffic safety, and pedestrian travel to varying degrees. This study uses a Cave Automatic Virtual Environment (CAVE) to examine the impact of different weather and visibility conditions on pedestrian road-crossing behaviors and perceived risk at midblock crossings in Hong Kong. By using CAVE technology, the study provides a controlled, immersive environment where pedestrians can engage in potentially dangerous situations and receive immediate feedback on their risk perception after each crossing. A total of 25 males and 25 females performed 30 road-crossing trials, combining different vehicle speeds, gap sizes, and weather conditions in the CAVE. A causal inference approach, specifically the inverse probability of treatment weighting with multilevel data for multiple treatments, was applied. The results indicate that pedestrians' risk perception values are higher when crossing the road on rainy and foggy days compared to good weather conditions. Additionally, pedestrians perceive crossing the road at dusk on rainy days to be more dangerous than during the daytime. The study also found that pedestrians perceive a higher risk when crossing the road in heavy fog compared to other weather conditions, likely due to decreased visibility. These results have significant policy implications for developing and implementing proactive traffic management systems.

Keywords: Pedestrian crossing, Risk perception, Weather condition, Virtual Reality, Causal inference approach

# Paper List

| Paper ID | Authors | Title | Session (P: poster session) |
|---|---|---|---|
| 5 | Weemeng Yeo | Pricing strategies in demand-responsive transport services | F3 |
| 7 | Kannapha Amaruchkul and Sarawut Jansuwan | Modeling a Risk-Averse Air Freight Forwarder's Capacity Management Under the Post-Pandemic Demand and Flight Time Uncertainties | B6 |
| 13 | Jiemin Xie, Fanghao Fu, Shuguang Zhan, Ming Cai and S.C. Wong | An integrated optimization model for elderly-friendly public bus planning | B5 |
| 14 | Richard Klophaus | EXPLORING PASSENGER AIRLINE NETWORKS BEYOND HUB-AND-SPOKE AND POINT-TO-POINT: OPPORTUNITIES AND CHALLENGES | B6 |
| 15 | Shulin Huang, Cheng Zhang and Jing Zhao | Traffic origin–destination matrices prediction with consideration of travel frequency | P5 |
| 17 | Hidenobu Matsumoto and Koji Domae | Competitive or Complementary Relations among Primary Airports in Japan from a Hub Performance Perspective | B6 |
| 18 | Jie Huang, Xiong Meicheng and Jiaoe Wang | Understanding urban spatial structure through the lens of multiple modal accessibility | D3 |
| 19 | Roger Vickerman | Reappraisal of Transit-Oriented Development | D3 |
| 20 | Hui Wang and Becky P.Y. Loo | Dynamics of In-Station Time within Metro Systems: Measurement and Determining Factors | E5 |
| 21 | Xin Guo, Zhenbin Zhang, Huijun Sun, Xiujiao Bi and Jin Zhou | A flexible multi-set strategy for cross-line routing operating in urban rail transit to address high-density, short-term transfer passenger demand | P5 |
| 23 | Mingxuan Chen and Wai Yuen Szeto | An e-bike repositioning problem with charging and non-charging docks | A5 |
| 25 | Yaochen Ma, Hai Wang and Hai Yang | Optimising timetable schedules considering non-traffic hour maintenance window on urban rail transit system | A1 |

| | | | |
|---|---|---|---|
| 26 | Chin Sum Shui and Yuk Chau | Multi-period bicycle network design using Genetic Algorithm | P7 |
| 27 | Yun Ye, Haoyang Liang, Jian Sun and Xiqun Chen | Distance-Informed Neural Eikonal Solver for Reactive Dynamic User-Equilibrium of Macroscopic Continuum Traffic Flow Model | P5 |
| 28 | Jia Cui and Wai Yuen Szeto | Optimizing Battery Swapping and Bike Repositioning Strategies for Electric Bike-Sharing Systems | F6 |
| 29 | Jiguang Wang, Xinglu Liu and Jintao Ke | A Predict-Decompose Algorithm for On-demand Dynamic Ride-pooling Problem Considering Order Cancellations | P6 |
| 30 | Yong Chen, Ningke Xie, Haoge Xu, Xiqun Chen and Der-Horng Lee | A Multi-Context Aware Human Mobility Prediction Model Based on Motif-Preserving Travel Preference Learning | P3 |
| 31 | Taijie Chen, Jian Liang, Ya Zhao and Jintao Ke | To grab or not to grab? Revealing determinants of drivers' willingness to grab orders under the broadcasting mode | D4 |
| 32 | Jian Liang and Jintao Ke | Order assignment for on-demand food delivery service considering driver behavior | D4 |
| 33 | Suwicha Jaita, Songyot Kitthamkesorn and Sathaporn Opasanon | Drone-Transit Cooperation for Last-Mile Delivery: A Maximal Covering Location Problem Approach | D6 |
| 35 | Zhixuan Li and Becky Loo | Innovations in the electric vehicle industry: Insights from two decades of patent data | F6 |
| 36 | Jianbiao Wang and Tomio Miwa | Analyzing Seniors' Unrealized Leisure Needs Considering Interactive Effects of Their Clinic Visits: A Copula-Based Approach | B5 |
| 37 | Shihan Wang, Ying Ni, Jian Sun and Jie Sun | Modelling the social interactions at mixed-flow intersection with multi-agent imitation learning | E4 |
| 39 | Guangnan Zhang, Qiaoting Zhong, Ying Tan and Qingxuan Yang | Risky behavior analysis for cross-border drivers: A logit model and qualitative comparative analysis of odds of fault and injury vulnerability in Guangdong, Hong Kong and Macau | P5 |
| 40 | Tang Liangji, Wang Fangsheng and Hong Ling | A Passenger Behavior Simulation Model for Metro Transfer Corridor Considering Commercial Attraction | P7 |

| | | | |
|---|---|---|---|
| 41 | Yuhang Yang and Shuyang Zhang | GNN-based explainable traffic congestion prediction with GNNExplainer | P3 |
| 42 | Wenzhang Yang, Changyin Dong, Ziqian Zhang, Xu Chen and Hao Wang | Enhancing On-Ramp Area Control in Heterogeneous Traffic Flow: A Dual-Module Cooperative Approach for Connected and Automated Vehicles Leveraging Reinforcement Learning | P1 |
| 44 | Xiangyi Li, Rosana W.M. Wong and Becky P.Y. Loo | Applications of the agent-based model to estimate the environmental impacts of construction on the neighbourhood | F1 |
| 45 | Qingnan Liang, Xin-An Li, Zhibin Chen, Tianlu Pan and Renxin Zhong | Day-to-day traffic control for networks mixed with regular human-piloted and connected autonomous vehicles | E4 |
| 46 | Pritam Saha, Suchismita Nayak and Soumen Mitra | EXPLORING PARA-TRANSIT CHOICE BEHAVIOUR IN PERI-URBAN AREAS OF KOLKATA, INDIA | B5 |
| 48 | Andreas Keler, Daijiro Maeda, Satoshi Nakao and Jan-Dirk Schmöcker | Relating Simulated Traffic Conflicts with Traffic Accident Records – Findings from the Gojo Dori Scenario in Kyoto | B2 |
| 49 | Andreas Keler, Tomoki Nishigaki and Jan-Dirk Schmöcker | Constructing a Public Transport Simulation by Fusing Open Source Data into SUMO with Kyoto Case Study | P7 |
| 51 | Tanhua Jin, Eric Koomen and Zheng Liang | What contributes to individual's '15-minute city' travel behavior? An investigation of a national travel survey in the Netherlands | P8 |
| 54 | Qi Wang, Xin Wen and Sai-Ho Chung | Deep Reinforcement Learning for Solving the Integrated Airline Recovery Problem | C6 |
| 55 | Lutz Prof. Dr. Gaspers | Satisfying mobility needs in rural areas through Car-Sharing | P5 |
| 56 | Anupriya Anupriya and Daniel Graham | Recreational Marijuana Legalisation: Has traffic safety worsened in the US? | P7 |
| 57 | Yunqiao Xiang, Yun Wang, Xuedong Yan, Yu Zhou and Qingwan Xue | Optimizing bus depot location and bus fleet allocation for both regular bus services and bus bridging services in response to urban rail transit disruptions | A1 |

| | | | |
|---|---|---|---|
| 58 | Yuhao Liu, Zhibin Chen and Joseph Chow | Robust Location for Quarantine Facilities under Decentralized Room Assignment: A Bi-level Mixed-Integer Programming Approach | F4 |
| 60 | Kehua Chen, Yuhao Luo, Meixin Zhu and Hai Yang | Interactive Human-Like Discretionary Lane-Changing Modeling Based on Reward-Guided Diffusive Planner and Predictor | C3 |
| 62 | Bo Wang, Jian Zhang, Ruolin Zhao and Ke Zhang | A Learning Network via Multi-stage Spatial–Temporal Feature Selection for Short-Term Traffic Flow Prediction | A3 |
| 63 | Yanqin Chen, Changxin Liao, Jia Yao, David Z. W. Wang and Anthony Chen | Modeling the effect of capacity constraints and queuing toll policies in the bi-modal traffic network incorporating carpooling behavior | E2 |
| 64 | Qiande He, Wai Yuen Szeto and Yi Wang | A modified genetic algorithm for solving the bus route design, express bus service design and frequency setting problem | D1 |
| 65 | Lulu Yang, Zhang Chen, Di Zhao, Yingdong Yao and Tianxu Li | A new method for non-destructive diagnosis of semi-rigid base damage condition of asphalt pavement | P3 |
| 66 | Mingrui Liu and Wai Yuen Szeto | Bus network design with the integration of limited-stop and autonomous bus services | D1 |
| 67 | Kazuma Hayashi and Toru Seo | Estimating source of traffic congestion from vehicle trajectory data using hierarchical Bayesian model | P7 |
| 68 | Ruyi Feng, Huihuang Zhu, Zhibin Li, Bowen Liu and Sze N.N. | TrTr: A Versatile Pre-Trained Large Traffic Model based on Transformer for Capturing Trajectory Diversity in Vehicle Population | P4 |
| 69 | Hing Yan Tong and Sheung Man Simon Yuen | Investigating the Unique Driving Patterns of Public Light Bus in Hong Kong | C4 |
| 70 | Haoyang Liang, Mun On Wong and Jian Sun | RTCROWD: REAL-TIME CROWD SIMULATION IN THE IMMERSIVE VIRTUAL ENVIRONMENT | C3 |
| 72 | Ruinan Wang, Zhibin Chen and Zhengtian Xu | Revealing Charging Patterns of Electric Vehicles with Intrinsic Usage Heterogeneity | P2 |
| 73 | Ning Lyu and Tao Feng | Integrated Planning of Vertiports and Vertipads Infrastructure for Urban Air Mobility | E3 |

| | | | |
|---|---|---|---|
| 75 | Zinuo Cao, Wanshan Li, Sujun Sun and Xin Xia | A BI-LEVEL REINFORCEMENT LEARNING METHOD FOR CUSTOMIZED BUS PLANNING CONSIDERING DYNAMIC PASSENGER INTERACTIONS | P6 |
| 76 | Jiaxin Lin, Tsan-Ming Choi and Yong-Hong Kuo | Will Providing Return-Freight-Insurances Do More Good than Harm to Dual-Channel E-Commerce Retailers? | D4 |
| 77 | Shen Zijian, Jiguang Wang, Taijie Chen and Jintao Ke | PERSONALIZED FAIR MATCHING IN PEER-TO-PEER RIDESHARING PLATFORMS UNDER BROADCASTING MODE: A LLM-DRIVEN DRIVER APPROACH | P6 |
| 78 | Jingmin Lin, Chunhui Yu, Benwei Chen and Wanjing Ma | Coordinated Distributed Trajectory Planning for Connected and Autonomous Vehicles at Expressway Bottlenecks under Mixed Traffic Environment | E1 |
| 79 | Pin Yin Chiang and Chin Sum Shui | Green family vehicle routing problem | F1 |
| 81 | Heejo Kim, Hyungkeun Son and Dongjoo Park | Integrating Excess Demand Data into Transportation Planning for South Korea’s Rail Network | P5 |
| 82 | Wenbo Sun and Fangni Zhang | A Reinforcement Learning Method to Solve Dynamic Truck-Drone Routing Problem | C6 |
| 83 | Alvin Noviansyah, Nobuhiro Uno, Ryoji Matsunaka and Tomoki Nishigaki | Understanding Mobile Behavioral Dynamics Across Diverse Activity Zones through Population Data Analysis | B5 |
| 84 | Yuan Zheng, Yue Fang, Shen Li, Yu Zhang, Lu Bai and Bin Ran | ROBUST STRING-STABLE CAR-FOLLOWING CONTROL FOR CONNECTED AND AUTOMATED VEHICLES UNDER MULTIPLE-SOURCE INFORMATION DELAYS | E1 |
| 87 | Tianxiang Fan, S.C. Wong, Zhiwen Zhang and Jie Du | STOCHASTIC LIGHTHILL-WHITHAM-RICHARDS TRAFFIC-FLOW MODEL FOR NONLINEAR SPEED-DENSITY RELATIONSHIP | P7 |
| 88 | Shuntaro Mega and Daisuke Fukuda | Route Choice and Traffic Equilibrium Considering A Driver Suboptimal Information Acquisition Strategy: The Deluded Rational Inattention Approach | C5 |
| 89 | Dong Liu, Mei-Po Kwan, Jianwei Huang, Zihan Kan, Yimeng Song and Xuefeng Li | Unveiling Inequality in Nodal Accessibility of Public Transportation for Sustainable Urban Development | D3 |

| | | | |
|---|---|---|---|
| 90 | Jiang Qian Ying | Urban economic analysis incorporating a quasi-dynamic traffic assignment model | E2 |
| 91 | Lei Wang and Hongbin Liang | Resource Allocation for Dynamic Platoon Digital Twin Networks: A multi-Agent Deep Reinforcement Learning Method | P2 |
| 92 | Tianfang Ma, Xuecheng Tian, Yan Liu and Shuaian Wang | ANALYSIS OF REWARD PROGRAMS FOR LINER SHIPPING SERVICES | P5 |
| 93 | Tao Li, Zhanbo Sun, Hongliang Ding, Ruiqi Wang, Zhijian Fu and Ang Ji | Effect of vehicle velocity on pedestrian movement at crosswalks: A case study using empirical data | D5 |
| 94 | Yaxin Wu, Xiaowei Hu, Jiyong Liao, Yujia Wang and Yu Jiang | Modelling Dynamic Spatial-temporal Carbon Emission Exposure with Heterogeneous Traffic Flows | F1 |
| 96 | Huihuang Zhu, Ruyi Feng and Zhibin Li | EFFICIENT MODEL COMPRESSION FOR IMPROVING TRAFFIC OBJECT RECOGNITION USING LIGHTWEIGHT PRUNING ALGORITHM | P1 |
| 97 | Soyeon Lee, Jihye Byun, Dong Ngoduy and Seunghyeon Lee | Optimal dynamic allocation problems of dedicated lanes for pedestrians in a heterogeneous transport network | D2 |
| 98 | Changlin Li and Hongbo Ye | Machine-learning-aided mixed-integer linear programming for solving transportation and logistics problems | C6 |
| 99 | Dongyu Tian, Zhibin Li, Ruyi Feng, Shunchao Wang and Si Zheng | TDI: Non-visual Intelligent Highway System Debris Identification Algorithm Based on High-Resolution Trajectory | A3 |
| 100 | Liang Ma, Kai Reis Darius Cooper, Marc E.J. Stettler and Daniel J. Graham | Did a Transformative Public Transport Investment Improve Air Quality? Elizabeth Line in London | F5 |
| 101 | Anupriya Anupriya and Daniel Graham | Modelling the expected performance of urban rail transport operations for benchmarking | F2 |
| 102 | Shouyi Wang and Andy Chow | Adaptive routing and scheduling of network-wide rail transit services with flexible train composition | A4 |
| 103 | Shaocheng Jia, S.C. Wong, Wai Wong and Xin Pei | REAL-TIME ESTIMATION OF RESIDUAL VEHICLES AT A SIGNALIZED INTERSECTION VIA PARTIAL CONNECTED VEHICLES | E1 |
| 104 | Th Eric Chan, Tingting Li and Tim Schwanen | The acceptance of Advanced Aerial Mobility (AAM) in China: Combining Trust with extended Technology | E3 |

| | | | |
|---|---|---|---|
| | | Acceptance Model and Theory of Planner Behaviour | |
| 105 | Dongdong Oliver Feng and Sylvia Y. He | Understanding public opinions of autonomous vehicles in China: A social media analytics approach | E6 |
| 108 | Ting Wang, Dong Ngoduy, Takao Dantsuji and Ye Li | Traffic state distributional estimation based on stochastic physics-informed deep learning | C2 |
| 109 | Daijiro Maeda, Andreas Keler, Satoshi Nakao and Jan Dirk Schmoecker | Analysis of Traffic Accidents Considering the Field of View | B2 |
| 111 | Runda Chen, Sujun Sun and Fangtong Liu | Optimization of Multi-discount Fare Setting for Public Transit Considering Travel Frequency Distribution | P6 |
| 113 | Zhibin Chen, Yanling Deng, Chi Xie, Chenghe Guan and Tianlu Pan | Network equilibrium of battery electric vehicles considering drivers' resting behavior | B1 |
| 114 | Yingying Sun and Wai Yuen Szeto | Coupling and Decoupling Tactics of Modular Autonomous Vehicles for Integrated Passenger and Freight Transport | E4 |
| 115 | Yingming Yao, Xiang Zhang, Jingwen Li and Fengxin Dai | A bi-level optimization model for multimodal transport resource allocation and pricing considering shipper preference | A4 |
| 116 | Yilin Liu | Integrating UAV Technology in Last-Mile Delivery: A Case Study of The Topical in India and Its Implications for Smart Urban Mobility | P3 |
| 118 | Yifan Zhao, Lubing Li, Zhiyuan Zhou, Chak Y. Lo and Hong K. Lo | Coordinated Traffic Signal Control: Deep Reinforcement Learning with Fundamental Traffic Flow Features | B3 |
| 119 | Hee Dong Ha and Do Gyeong Kim | STRATEGIES FOR QUEUE-BASED SKIP-STOP SCHEME IN EXCLUSIVE MEDIAN BUS LANE | C4 |
| 120 | Shenglin Liu, Qian Ge and Ke Han | Mechanism design for coordinating vehicle-based mobile sensing tasks within the ride-hailing platform | P3 |
| 121 | Wenjia Zeng, Ruiwei Jiang, Hai Yang and Hai Wang | Two-stage Drone Delivery Network Design with Uncertain Demand | P5 |

| | | | |
|---|---|---|---|
| 122 | Hyunseop Sim and Shin Hyoung Park | Optimizing Vehicle Responses in Accident Scenarios: A Reinforcement Learning Approach with V2X Communication | P1 |
| 124 | Jinwon Jang, Sangkyu Lee and Dongjoo Park | A Study on Travel Behavior Analysis of Container Semi-Trailer Truck by Travel Type | P5 |
| 125 | Yini Chen, Rao Fu and Shuai Jia | Flying Path Planning with Ground Risk and Noise Mitigation for Urban Air Mobility | E3 |
| 126 | Xindi Tang, Xiaozhuang Li, Fang He and Yang Liu | Online Operations of a Mixed-fleet Ride-hailing Service System Catering to Specialized Needs of Seniors | F3 |
| 127 | Tong Nie, Guoyang Qin, Wei Ma and Jian Sun | Generalizable Implicit Neural Representation As a Universal Spatiotemporal Traffic Data Learner | P2 |
| 129 | Lei Yu, Qian Ge and Ke Han | Optimal subsidy scheme design for construction and demolition waste recycling | P6 |
| 130 | Zhiyuan Zhou, Lubing Li, Yifan Zhao, Ka Fai Ng and Hong K. Lo | Bayesian Traffic State Estimation for Adaptive Traffic Control | B3 |
| 131 | Zhicheng Jin and Xiaotong Sun | Powering the Ride: A Spatial Investigation Over Charging Demand of Electrified Ride-Hailing in Shanghai | P3 |
| 132 | Shuli Luo | The effect of eye-level built environment on metro-bicycle integration: integrating street view images with deep learning techniques | A1 |
| 134 | Shishu Shen, Xiang Zhang, Ning Ma and Yan Huo | Modelling the electric vehicle routing problem with drones under wireless charging lanes provision | P1 |
| 135 | Yangyang Meng, Xiaofei Zhao and Wei Ma | Exploring the dynamic evolution of passenger flow fluctuations in urban complex metro networks | P6 |
| 136 | Seulbin Hong, Jihye Byun, Wai Wong and Seunghyeon Lee | A group-based adaptive emergency vehicle priority signal system | B3 |
| 137 | Jiajie Yu, Yuhong Wang and Wei Ma | Large Language Model-Enhanced Reinforcement Learning for Generic Bus Holding Control Strategies | P4 |
| 138 | Shuo Jiang, Ran Yan and Poong Oh | Extracting Maritime Traffic Route Network from Automatic Identification System Data | A2 |

| | | | |
|---|---|---|---|
| 139 | Yitong Zhang, Qian Ge and Ke Han | An auction-based driver assortment approach for unattractive ride-hailing orders considering the drivers' preferences | P3 |
| 140 | Xiangcheng Li, Xiaotong Xu and Wei Ma | A city-scale traffic dataset for comprehensive urban research in 10 UK cities | P5 |
| 143 | Yanling Deng, Zhibin Chen and Xi Lin | Cost-competitiveness analysis of mobile chargers in an electric vehicle parking and charging system | P1 |
| 144 | Xin Zhang, Jiemin Xie and Gege Jiang | OPTIMAL OPERATING STRATEGY OF THE RIDE-SOURCING COMPANY UNDER MARKET AGGREGATION | P6 |
| 145 | Hongzheng Shi, Jiguang Wang and Jintao Ke | Optimal Tour Length Estimator for Vehicle Routing Problems in Real Road Networks Using Graph Neural Networks | P4 |
| 146 | Qilong Li and Haohan Xiao | Blockchain-based Cross-border Logistics Platform Operations: A Game-theoretic Analysis | P5 |
| 147 | Jiatong Song, Wai Yuen Szeto, Baicheng Li and Yi Wang | A HYBRID E-BIKE SHARING SYSTEM DESIGN PROBLEM CONSIDERING MULTIPLE TYPES OF FACILITIES | A5 |
| 148 | Hyeokju Nam, Jihye Byun, Dong Ngoduy and Seunghyeon Lee | A BI-LEVEL CALIBRATION METHOD OF MICROSCOPIC CAR-FOLLOWING MODELS BASED ON DYNAMIC TRAFFIC FLOW | A3 |
| 150 | Fan Gao and Sylvia Y. He | Introducing geographically weighted LightGBM (GWLGBM) models: A new spatial machine learning model | C5 |
| 153 | Soyeon Lee, Jihye Byun, Haoyang Liang and Seunghyeon Lee | A hybrid calibration method of parameters in microscopic pedestrian behavioral models under high-density walking environment | C3 |
| 156 | Qiu Hao and Zhang Jinlei | Spatial-Temporal Multi-Task Learning for Short-Term Passenger Inflow and Outflow Prediction on Holidays in Urban Rail Transit Systems | C6 |
| 157 | Chen Xi, Wong Sze Chun and Yang Liangze | Developing and Solving a Stochastic Second-order Traffic Flow Model based on Multi-element Probability Collocation Method | C2 |

| | | | |
|---|---|---|---|
| 158 | Xinyu Wang and Wei Ma | An end-to-end predict-then-optimize method for on-demand vehicle reallocation in mobile sensing | P1 |
| 163 | Xiaohan Wang, Xiqun Chen, Chi Xie and Taesu Cheong | Coordinative Dispatching of Shared and Public Transportation under Passenger Flow Outburst | P3 |
| 164 | Taijie Chen, Jingyun Liu, Zhongyou Hu, Siyuan Feng and Jintao Ke | A Top-to-Bottom Reposition Method for Ride-hailing Platforms | B4 |
| 169 | Jiaomin Wei, Zihan Kan, Mei-Po Kwan, Zhuo Liu, Yanyan Chen and Yang Wang | Correlation between the built environment and dockless bike-sharing trips connecting to urban metro stations | P8 |
| 170 | Yimo Yan, Yonghong Kuo, Yang Deng, Qihao Wu and Andy Chow | A Mixed-Integer Programming-based Q-Learning Approach for Electric Bus Scheduling with Multiple Termini and Service Routes | C4 |
| 174 | Sirui Hong and Jiuh-Biing Sheu | Green services operations for electric vehicle battery charging and swapping service modes | F6 |
| 178 | Miaoqing Hu and Wai Yuen Szeto | INTEGRATED DESIGN OF URBAN RAIL TRANSIT FED BY FEEDER BUS AND SHARED BIKE | A4 |
| 182 | Rami Al-Shukairi, Liang Ma, Marc E.J. Stettler and Daniel J. Graham | Integrating Spatial Insights with Machine Learning to Estimate Annual Average Daily Traffic by Vehicle Type on Local Roads | P5 |
| 184 | Takao Dantsuji, Dong Ngoduy, Ziyuan Pu, Seunghyeon Lee and Hai Vu | A HYBRID NEURAL NETWORK FOR REAL-TIME OD DEMAND CALIBRATION UNDER DISRUPTIONS | A3 |
| 187 | Jun Li and Quan Yuan | Transportation Safety-based Obstacle Detour Path Planning Method for Automated Vehicles | C3 |
| 188 | Masahiro Yoshimura, Satoru Kobayakawa and Noriyasu Tsumita | Analysis of pedestrian crossing behaviors at unsignalized crosswalks on four-lane bidirectional roads | D5 |
| 189 | Mehrdad Memarpour, Taha Hossein Rashidi, Steven Travis Waller and Ali Najmi | Active network optimisation: addressing conflicts between ethics and fairness in transport networks | E2 |

| | | | |
|---|---|---|---|
| 192 | Runqiu Hu and Wai Yuen Szeto | Repositioning in bike sharing systems with broken bikes considering on-site repairs | A5 |
| 194 | Meng Liu and Sylvia He | Evaluating the spatial layout of public charging infrastructure for e-taxis using GPS trajectory data | P1 |
| 195 | Yuxin Wang, Feihong Yu, Man Fung Ho, Bo Peng, Qinhan Wen, Qiaowen Tan, Tat Shing Choi and K.Y. Michael Wong | PREDICTION OF LANDING TIME DELAYS WITH MULTIPLE APPROACHING ROUTES TO AN AIRPORT | C1 |
| 196 | Yifan Li, Ziyuan Gu, Nan Zheng, Wei Ma and Zhiyuan Liu | Macroscopic Modeling and Optimization of Two-Region Mixed Autonomy Network with Park-and-Ride | E4 |
| 198 | Barbara T.H. Yen, Corinne Mulley, Shuo-Chen Hsieh and Yu-Wen Pai | Classifying Performance Level of Demand Responsive Transport Services in Taiwan: A Context-dependent Data Envelopment Analysis | F3 |
| 203 | Zhenwei Gong, Zhuoye Zhang and Fangni Zhang | On the network equilibrium of an integrated air-ground urban transport system | A6 |
| 204 | Theeranai Pullarp, Hyungsub Jee, Jan-Dirk Schmöcker and Kari E. Watkins | Analysing bus usage and public transport accessibility impacts from long-term crowd-sourced trajectory data | D1 |
| 205 | Nitya Visvanathan and Hooi Ling Khoo | Assessment of Potential Shared Space Street Using Analytic Hierarchy Process (AHP): A Case Study in Klang Valley, Malaysia | D2 |
| 207 | Fu Chiang, Chia-Jung Yeh, Xin Wang and Yu-Cheng Ting | Performance Evaluation Scope: Comparing Route Based and Region Based Evaluation in Public Transport | P5 |
| 208 | Youngryeong Lee, Juhyeon Kwak, Minje Choi and Seungjae Lee | Graph Convolutional Networks Based Dynamic Taxi Route Recommendation | B4 |
| 209 | Yumi Hazenoki, Takanori Sakai, Hideki Oka and Tetsuro Hyodo | Unveiling heterogeneity of urban goods vehicles' route choice behavior: Analysis using GPS data from the Tokyo Metropolitan Area | P5 |
| 211 | Xuan He and Sylvia He | Decoding the spatial effects of walkability on walking behavior among older adults by integrating big data and small data | B5 |

| | | | |
|---|---|---|---|
| 212 | Xuling Liu and Xiaoning Zhang | Cooperative Lane-Changing Optimization of Connected and<br>Autonomous Vehicles in Freeway Merging Area | E1 |
| 213 | Kai Qu, Xiangdong Xu and Anthony Chen | Improving Transportation Network Redundancy by Integrating<br>Link Addition and Link Retrofitting | P7 |
| 215 | Zhuowei Wang, An Wang, Anthony Chen and Hongxing Yang | Assessing zero-emission bus market in Hong Kong from a<br>lifecycle perspective | F5 |
| 216 | Canqiang Weng, Can Chen, Tianlu Pan and Renxin Zhong | A Hybrid Framework of Traffic Simulation and Management for<br>Large-scale Urban Air Mobility | E3 |
| 218 | Yiqing Liang and Becky P.Y. Loo | Technological advances in rural logistics: the benefits of<br>electric cable cars | P3 |
| 219 | Heqing Tan, Xiangdong Xu and Anthony Chen | Obviating Explicit Matrix Manipulation for Exact Gradient<br>Evaluation of Mathematical Programs with Equilibrium<br>Constraints | A6 |
| 222 | Kouki Matsumoto, Masaaki Ishihara and Takamasa Iryo | A fast algorithm for computing route choice probabilities<br>in large-scale dynamic road networks | E5 |
| 225 | Ara Cho, Minje Choi, Sion Kim, Ilho Jeong and Seungjae Lee | Predicting Electric Bus Power Consumption Considering Bus<br>Route Characteristics | B4 |
| 226 | Maoning Chen and Hongbo Ye | Scheduling of Autonomous Modularized Trains Under Virtual<br>Coupling Signaling | A1 |
| 229 | Takahiro Matsunaga and Eiji Hato | JOINT ESTIMATION OF LATENT OD MATRIX AND 3D ROUTE CHOICE<br>MODEL ACROSS RAILWAY STATION BOUNDARIES BASED ON MANIFOLD LEARNING | E5 |
| 230 | Yu Gu and Anthony Chen | Considering path order and perceptual correlations in a<br>tolled network with ordered GEV model | P7 |
| 231 | Ryuhei Kurasawa, Eiji Hato and Xiao Fu | CAUSAL ANALYSIS OF THE IMPACT OF TELEWORK DURING COVID-19<br>ON ACTIVITY CHOICE BEHAVIOR IN TOKYO | F4 |
| 232 | Enoch Lee, Manzi Li, Lubing Li and Hong Lo | Integration of flexible bus and parcel with ad hoc service<br>under stochastic demand and service time | D1 |

| | | | |
|---|---|---|---|
| 234 | K.I. Wong and J.S. Lin | Traffic conflict analysis with surrogate safety measures by latent representations | P4 |
| 236 | Ce Wang, Jintao Ke and Kaihang Zhang | Modelling the Ride-sourcing Market under Broadcasting Matching Mode | B4 |
| 237 | Jie Lin and Fangni Zhang | Online Optimization of Integrated Charging and Parking Services considering Vehicle Relocation | P3 |
| 238 | Satoki Masuda and Eiji Hato | Dynamic Reconfiguration Strategies for Managing Shelter and Road Congestion in Urban Emergency Evacuations | F4 |
| 239 | Zhongyu Sun, Jiangbo Wang and Kai Liu | Customized Commuting Bus Routing Under Carbon Emissions Regulations | F1 |
| 240 | Dongze Li and Fangni Zhang | Joint Optimization of Incentive and Routing Strategies in Crowdsourced Last-Mile Delivery | P3 |
| 245 | Daichi Ogawa and Eiji Hato | Lipschitz continuity in interaction for stable equilibrium of multi-agent joint choice models | E2 |
| 246 | Xu Zhang and Zhiman Xu | EVALUATING TRAFFIC PERFORMANCE OF DEDICATED LANES FOR CONNECTED AND AUTOMATED VEHICLES AT URBAN ROUNDABOUTS | P1 |
| 247 | Zhi Li, Zhibin Chen, Hailong Li, Chenghe Guan and Minghui Zhong | On the Value of Orderly Electric Vehicle Charging in Carbon Emission Reduction | P3 |
| 250 | Huiying Lei, Xuedong Hua, Weijie Yu, Yongtao Zheng and Wei Wang | Analysis of Cascading Failure in Urban Metro Networks: A Dynamic Perspective Incorporating Changes in Travel Decisions | P6 |
| 251 | Umer Mansoor, Zhengyang Li, Guoyuan Li and Anthony Chen | A continuous bi-criteria traffic assignment model with safety consideration | B2 |
| 254 | Barbara T.H. Yen, Chia-Jung Yeh, Yu-Chiun Chiou and Jin-Yuan Wang | Unveiling the Impact of Bus Network Design on Route Choice: An Empirical Review from Smartcard Data | P7 |
| 256 | Fumihito Furuhashi | Validation of an innovative car-following model using GNNs and PINNs with multi-modal AI on On-Board Diagnostics | A3 |

| | | | |
|---|---|---|---|
| 257 | Wenfei Ma, Yunping Huang, Xiao Jin and Renxin Zhong | Uncertainty quantification approaches of macroscopic fundamental diagrams in urban networks | C2 |
| 258 | Peilin Zhao, Yiik Diew Wong and Feng Zhu | Hysteresis Phenomenon in Traffic Safety Analysis | P7 |
| 262 | Ahmad El Bukhari, Lina Kattan, William H. K. Lam and Wei Ma | Spatially Continuous Real-Time Network-Wide Flow and Density Estimation and Prediction Based on Shockwave Dynamics | C5 |
| 264 | Heesoo Kim, Nobuhiro Uno, Ryoji Matsunaka and Tomoki Nishigaki | Leveraging VIIRS NTL Data to Assess the Impact of Rail Systems on Japanese Cities. | D2 |
| 265 | Rong Cao and David Z W Wang | From Incomplete Data to Full-Scale Traffic Prediction: An Iterative Framework with Direction-Based Traffic Data | C5 |
| 268 | Qingyang Li and Fangni Zhang | On Order Allocation and Payment Schemes for an Auction-based Crowd-shipping Platform | D4 |
| 274 | Zhuangyuan Fan and Becky P.Y. Loo | Urban Visual Clusters: Image analysis of global road transport fatalities | B2 |
| 275 | Jiazu Zhou, Seanglidet Yean, Tianyu Dong, Bu Sung Lee and Markus Schläpfer | Flattening the electricity load profile with electric vehicles considering urban mobility | B1 |
| 277 | Jing Wang, Jian Zhao, Kai Liu and Jiangbo Wang | Integration Study of Individual Travel Prediction and Passenger Flow Forecasting: Based on the Individual Travel Patterns of Rail Transit Passengers | F2 |
| 279 | Ruifeng Gu and Nang Ngai Sze | Influences of individual heterogeneity on vehicle damage in two-vehicle lane-changing related crashes: A copula-based model | C3 |
| 280 | Muqing Du, Dongyue Cun, Guoyuan Li and Anthony Chen | A Two-phase Approach for Multimodal Traffic Equilibrium Assignment based on Network Generalized Extreme Value Model | E2 |
| 281 | Jun Gong and Wai Yuen Szeto | A MULTI-PERIOD ASYMMETRIC TRANSIT FREQUENCY DESIGN | D1 |
| 285 | Hongjian Bai, Xiao Huang, Shenbo Shi and Yacan Wang | The effect of air quality on the distribution of tourists Based on mobile phone data | P2 |

| | | | |
|---|---|---|---|
| 287 | Siyao Zhang, Daocheng Fu, Wenzhe Liang, Zhao Zhang, Bin Yu, Pinlong Cai and Baozhen Yao | TrafficGPT: Viewing, Processing and Interacting with Traffic Foundation Models | C5 |
| 288 | Tianlei Zhu, Xin Yang, Anthony Chen, Guanwen Zeng and Jianjun Wu | Analysis of urban rail transit resilience under different operation schemes: A percolation-based approach | A1 |
| 289 | Qingying He and Wei Liu | Multi-service electric fleet management for rides, parcel deliveries, and vehicle-to-grid services | B1 |
| 291 | Huan Wu, Fang Zong, Meng Zeng and Pei-Xin Shi | The Right-of-way Assignment Strategy at the Intersection Approach Under Mixed traffic: Considering the Heterogeneity of HDV Drivers' Confidence in CAVs | E6 |
| 293 | Xinyu Chen and Sunghoon Jang | Impact of Perceived Service Quality of Drone Delivery Service on Behavioral Intention to Use | D6 |
| 296 | Shi Ye, Tiantian Chen, Oscar Oviedo-Trespalacios, Taeho Oh and Inhi Kim | Assessing Driver Decision-Making and Behavior in the Dilemma Zone Across Different Connected Environments: A Driving Simulator Study | P2 |
| 298 | Zixuan Xu, Neha Sengar and Tiantian Chen | How Does the Large Language Model Decide to Save Pedestrians or Passengers? Evaluation of Ethical Dilemmas in ChatGPT-Based Decision-Making of Autonomous Vehicles | A6 |
| 302 | Cheuk Kin Ho, Enoch Lee, Yue Huai and Hong Kam Lo | SPATIAL-TEMPORAL TAXI PROFITABILITY THROUGH DATA PREDICTIVE ANALYTICS | C4 |
| 303 | Yufan Zuo and Wei Liu | CAPACITY ALLOCATION OF PASSENGER AIRLINES FOR AIR CARGO TRANSPORTATION | C1 |
| 304 | Xu Guangming, Zhu Ziqi, Zhong Linhuan and Xiao Yini | Comprehensive Optimization for High-speed Railway Passenger Train Line Planning and Ticket Allocation under Random Demand | P7 |
| 305 | Stein W. Wallace, Feng Guo, Zhaoxia Guo and Michal Kaut | Practical Vehicle Routing in an Urban Road Network: Is Stochastic or Time-dependent Speed Important? | E5 |

| | | | |
|---|---|---|---|
| 307 | Yiping Liu, Tiantian Chen, Hyungchul Chung, Kitae Jang and Pengpeng Xu | How does subjective perception of streetscape affect traffic crashes? A spatial analysis for integrating safety into street planning | B2 |
| 309 | Qiaoqiao Ren, Chak Kei Li and Min Xu | Injury Severity Analysis of Road Traffic Accidents in Hong Kong: A Comparative Study before and during the COVID-19 Pandemic | P4 |
| 316 | Li Zhen and Weihua Gu | Optimal trunk-feeder transit network design under heterogeneous demand | A4 |
| 317 | Xiaokuan Zhao and Weihua Gu | Bounds and Approximations for Port Capacity with Two-Way Channels | A2 |
| 319 | Jiping Xing, Xiaohong Jiang and Kai Zhang | Incorporating mobile internet usage data to explore the impacts of human mobility patterns on shopping malls | P1 |
| 322 | Xiao Chu, Shuiwang Chen, Kai Wang, Lingxiao Wu and Gangyan Xu | Unlocking the Potential of Drones in Revolutionizing Intra-City Express Services: A Cost-Efficiency Analysis | P1 |
| 325 | Huiying Zhao, Huijun Sun, Hao Fu and Jianjun Wu | Optimizing EMS Responses Post-Disaster: Robust Allocation of Ambulances Considering Travel Time Uncertainties | P1 |
| 329 | Xuanji Long and Wei Liu | Joint Optimization of Airport Slot Allocation and Gate Assignment: A Stochastic Integer Programming Approach | C1 |
| 330 | Rongjie Sun, Zuoning Jia, Kun An and Shadi Sharif Azadeh | Candidate forward warehouses locations for the last mile fresh product delivery | P5 |
| 331 | Lin Yu, Yanyan Ding and Sisi Jian | Design of Smart Electric Vehicle Charging Services under Demand and Renewable Energy Uncertainties: A Two-stage Stochastic Optimization Model | P3 |
| 332 | Jinshu Cai, Yanyan Ding and Sisi Jian | Regulating Discriminatory Pricing against Existing Customers in the Transportation Market Considering Supply-demand Congestion Effects and Duopoly Competition | P1 |
| 333 | Xinyan Zhang, Jia Gao, Yushi Pan and Kun An | Joint optimization of scheduling and passenger matching for multi-route conventional and flexible integrated bus | P6 |

| | | | |
|---|---|---|---|
| | | services | |
| 335 | Xinyi Zhu and Wei Liu | Resource allocation in air-rail-integrated co-modality under both demand and supply uncertainties | B6 |
| 336 | Wenxin Zhou, Xiaolei Wang, Jie Yang and Xiaoning Zhang | Ridesharing user equilibrium model and its equivalent variational inequality formulation without monotonicity: A decomposition-based approximation approach | P3 |
| 337 | Bing Song and Sisi Jian | Privacy-Preserving Personalized Revenue management of Ride-Hailing Platform | B4 |
| 339 | Xiaolong Li, Xiaowen Fu and Daqing Gong | Subway expansion, road congestion, and urban air quality | F5 |
| 340 | Qihui Li, Nan Zhao and Páraic Carroll | DETERMINING RESIDENTIAL CHARGING STATION PLACEMENT BY INTEGRATING TRAVEL BEHAVIOURS AND POWER GRID CAPACITY CONSTRAINTS | B1 |
| 342 | Qingyun Tian, Yunhui Lin and Zhiwei Wang | Infrastructure-enabled automated network design for mixed traffic | E4 |
| 344 | Can Li, Guangming Xu and Xinyi Liu | Two-Stage Stochastic Optimization of Seat Allocation and Flexible Composition for High-speed Railway Considering the Uncertainty of Epidemic | P7 |
| 347 | Haosong Wen, Weijie Yu and Wei Wang | Evaluating the Safety Impact of Regional Communication Failures on Connected and Automated Vehicles | P1 |
| 348 | Hiroyuki Hasada, Anna Mizuno, Yuhan Gao, Seishu Kitamura and Ryo Kanamori | Comparison of new mobility services using RP-SP mode choice models considering latent variables and heterogeneity | E3 |
| 349 | Bolong Zhou, Wenjia Zeng, Wei Liu and Hai Yang | A Branch-price-and-benders-cut approach for optimizing the scheduling of urban subway inspection services using UAVs | D6 |
| 350 | Xiaolei Liu, Zhengyu Duan, Qing Yu and Mengyi Wang | Unraveling preference heterogeneity in metro route choice using mobile phone data | P4 |
| 352 | Ippei Morita, Anna Mizuno, Hiroyuki Hasada, Seishu Kitamura | Evaluation of novel mobility service mixed ride-share with shuttle bus for a shopping center in suburban | P3 |

| | | | |
|---|---|---|---|
| | and Ryo Kanamori | residential area | |
| 353 | Guoyu Huang, Wei Huang and Min Huang | A dynamic programming based framework for adaptive traffic signal control | B3 |
| 354 | Meiping Yun, Yijia Dong and Yue Ma | The Effects of COVID-19 on Work Pattern and Commuting Frequency in Shanghai: A Retrospective Survey Data Analysis | P7 |
| 355 | Yin Huang, Yongqi Dong, Youhua Tang and Li Li | Leverage Multi-source Traffic Demand Data Fusion with Transformer Model for Urban Parking Prediction | P1 |
| 356 | Yongqi Dong, Chang Liu, Yiyun Wang and Zhe Fu | Towards Understanding Worldwide Cross-cultural Differences in Implicit Driving Cues: Review, Comparative Analysis, and Research Roadmap | D5 |
| 358 | Xinyao Yu, Shoufeng Ma, Ning Zhu, Hongming Li and Jintao Ke | Optimizing Mobile Facility Planning for Disaster Response with Inequity Mitigation: A Lexicographic Distributionally Robust Optimization Approach | C6 |
| 359 | Gen Hayauchi, Ryo Kanamori and Takayuki Morikawa | An analysis of tourists' willingness-to-pay for bundled one-day transport ticket in the central Nagoya with the price sensitivity measurement | P1 |
| 360 | Yue Huai, Enoch Lee, Hong K. Lo and Anming Zhang | Airport's optimal decisions considering non-aeronautical business, terminal capacity and different regulatory regimes | C1 |
| 362 | Wei Zhou and Ghim Ping Ong | EXAMINING ELDERLY ACTIVITY IN SINGAPORE: THE ROLE OF PERCEIVED AND PHYSICAL ACCESSIBILITY | P8 |
| 363 | Dohyeon Kim, Sooncheon Hwang, Jihye Byun, Dongmin Lee, Wai Wong and Seunghyeon Lee | Integrating a time-dependent reactive local signal control policy with queue-based green light optimal speed advisory (Q-GLOSA) systems | B3 |
| 364 | Jiaqi Liu, Zheng Liang and Hong K. Lo | Estimation of Stochastic Origin-Destination Distribution based on Stochastic Link Counts | C2 |
| 365 | Mengrong Yan, Guangming Xu and Linhuan Zhong | Integrated optimization of railway capacity allocation and pricing for high-speed rail express delivery considering uncertain demand and uncertain capacity | P7 |

| | | | |
|---|---|---|---|
| 366 | Runfa Wu, Wei Liu and Yuzhen Feng | Joint optimization of seat allocation and pricing with<br>multi-ride season ticket service in the high-speed rail<br>system | A4 |
| 367 | Hyung Joon Bang, Youngkyun Kang, Dohoon Kim and Taekyoung<br>Kim | Identification of Hazardous Sections in Small-Vehicle-Only<br>Underground Roads Using 3D Simulation: A Case Study of the<br>Seobu Underground Expressway | P5 |
| 370 | Yisong Chen, Zhimian Wang, Kun An and Hai Jiang | Battery swapping station location and charging scheduling<br>for the e-bike sharing system under stochastic demand | P2 |
| 373 | Ria Roida Minarta, Jonghan Park and Joonho Ko | Factors Affecting the Acceptance of Autonomous Vehicles: A<br>Case Study of Seoul, South Korea | E6 |
| 374 | Kun Feng Wu, Tong Lin and Po-Jui Chen | Exploring the Crash Effects of Roadway Attributes and<br>Elements on Roadway Segments in an Urban Mixed Traffic<br>Environment | P8 |
| 379 | Taewoo Kim, Joonho Ko and Jonghan Park | Understanding public bike ticket choice with hourly travel<br>distance patterns: A case study of Seoul public bike system | A5 |
| 380 | Seungbin Im, Saehim Kim, Seunghwa Jang and Joonho Ko | Developing Bus Speed Prediction Model for Exclusive Median<br>Bus Lanes Considering Bus Travel Demand | C4 |
| 382 | Penglin Song and N.N. Sze | A COPULA-BASED APPROACH FOR JOINTLY MODELING INJURY<br>SEVERITIES OF DRIVERS AT VEHICLE LEVEL IN TRUCK-INVOLVED<br>CRASHES | P8 |
| 383 | Anam Hyder and Saladi S.V. Subbarao | Understanding Pedestrian Crossing Behaviour using Extended<br>Theory of Planned Behaviour: A case of Hyderabad, India | D5 |
| 384 | Peimin Wu, Xuan Ma and Xiao Fu | Impact of Electric Vehicle Promotion on Carbon Emissions<br>from Passenger Cars under Diverse Policy Scenarios | F6 |
| 385 | Sarawut Jansuwan | Implementing Digital Twin Solutions into Smart City<br>Infrastructure Management: Case Study of NIDA Smart Campus<br>in Thailand | D2 |

| | | | |
|---|---|---|---|
| 387 | Sifeng Wang, Guizhen Yu, Zhangyu Wang, Simiao Gao and Pengcheng Wang | Enhanced Object Detection Algorithm with Prediction Box Extension | P2 |
| 393 | Kim N. Dirks, Judith Y. T. Wang and Matthias Ehrgott | Air Pollution and Travel to School – Part I: A Theoretical Bi-modal School Trip Model | F5 |
| 394 | Timothy J. Amsdon, Judith Y. T. Wang, Jin Liu and Edward Brown | Air Pollution and Travel to School – Part II: A Cloud-based Smart App for Walking School Buses | F5 |
| 395 | Yunting Miao and Jiangping Zhou | Investigating and Enhancing Non-Metro Trips and Life between Stations: Insights from Hong Kong | P8 |
| 396 | Chin Long Ng, Yafei Wang, Bowen Wang, Zexing Li and Ruoyao Li | V-RP3D: Enhancing Roadside LiDAR-based Perception through Domain Generalization from Vehicle Perspective in 3D Object Detection. | P4 |
| 397 | Raj Prajapati, Gaurang Joshi, Sanjay Dave, Rohit Rathod and Janak Parmar | Understanding the Psychological Factors Affecting Non-Users' Adoption of Public Transportation: Case study of Surat, India | P2 |
| 403 | Jing Wang, Dong Yang, (Shuai Jia) | Can Renewable Fuels Power the Future of Green Shipping Corridors? A Comparative Assessment Framework | A2 |
| 409 | Yuting Hou, Jiemin Zheng, Xize Wang and Sylvia Y. He | Are Singapore's new towns self-contained? – An examination based on the post-COVID public transport smartcard data | D3 |
| 410 | Ziyu Cui, Xiaowen Fu, Xiangru Wu and Kun Wang | Economic Analyses on Electric Ships Adoption in Inland Water Transport and Government’s Optimal Subsidy Scheme Design | A2 |
| 411 | Jeong Seomun, Seunghyeon Lee and Jihye Byun | Adaptive Route Planning for Scheduling Autonomous Mobile Chargers for Electric Vehicles | E5 |
| 413 | Xiaokuan Zhao, Jie Ma and Weihua Gu | A planning model for multi-terminal electric bus system | P7 |
| 416 | Jingda Wu, Chao Huang and Hailong Huang | Representation Enhanced Behavior Planning using Vector Quantized Encoding for Autonomous Driving | P4 |
| 417 | Ting Sun, Jing-Peng Wang, Peng Liu, Yipu Niu and Rui Xue | Modeling and Optimization of On-demand Delivery Workforce Capacity with Endogenous Service Intensity | D4 |

| | | | |
|---|---|---|---|
| 421 | Kejun Du, Enoch Lee, Qiru Ma and Hong Lo | IDENTIFICATION, CATEGORIZATION AND RATIONALIZATION OF METRO PASSENGER REROUTING CHOICES UNDER METRO DISRUPTIONS WITH A HIERARCHICAL UTILITY-BASED ROUTE CHOICE MODEL | F2 |
| 423 | Yulu He, Wenliang Ma, Keke Fan and Kun Wang | THE IMPACTS OF EXCHANGE RATE FLUCTUATIONS ON THE INTERNATIONAL AIR PASSENGER TRANSPORT MARKET: THE CASE OF THE CHINESE INTERNATIONAL AIRLINE MARKET | B6 |
| 424 | Shi-Teng Zheng, Rui Jiang and Xiqun Chen | Communicating with only two vehicles immediately ahead boosts traffic capacity sixfold in connected autonomous vehicle (CAV) platoons | E1 |
| 425 | Yitao Yao, Bin Jia and Tingting Zhao | Criticality road segment identification for enhancing post-event network efficiency through Graph Attention Networks | F4 |
| 428 | Ce Hou, Yuhao Kang, Fan Zhang, Song Gao, Yong Li, Fabio Duarte and Sen Li | “Transferred bias” uncovers the balance between the development of physical and socio-economic environments of cities | D3 |
| 430 | Maria Attard | MOBILITY CHANGES UNDER WORK FROM HOME CONDITIONS: THE CASE OF MALTA | C5 |
| 431 | Khoa Vo, Eui-Jin Kim, Huichang Lee and Prateek Bansal | Fusing household travel survey and smart card data to generate spatiotemporally heterogeneous activity schedules for transit riders | F2 |
| 432 | Jinghai Huo, Eui-Jin Kim and Prateek Bansal | Understanding Consumers’ Non-Compensatory and Heterogeneous Preferences for Electric Vehicles | B1 |
| 433 | Tianyu Shang, Hao Wu, Dong Yang, Changmin Jiang and Kun Wang | How Does Shipping Alliance Affect Port Capacity Investment and Congestion | A2 |
| 434 | Yucong Meng, Wanshui Han and Shujun Chen | Model Correction Based on Self-Feedback Adjustment of Bulky Vehicle Over-bridge Response Monitoring Data | D2 |
| 436 | Nazam Ali and R.C.P. Wong | Promoting gender-inclusive transport and enhancing mobility of women | P7 |

| | | | |
|---|---|---|---|
| 437 | Jin Wang, R.C.P. Wong and W.Y. Szeto | Public acceptance and adoption of electric mobility devices for last-mile travel in Hong Kong | F6 |
| 438 | Carreen de Cardenas, Afrida Raida, Armanhosseini Aliabad, Eilise O'Connor, Arsalan Heydarian, Andrew Mondschein and T. Donna Chen | Measuring Pedestrian Perception and Behavior along an Urban Street during the Daytime and Nighttime through the use of Eye-Tracking Technology | D5 |
| 440 | Rong Zheng, Yuan Liang and Donggen Wang | Electric Assistance Offers Greater Temperature Resilience for Active Travel Modes: Evidence from Citi Bike in New York City | A5 |
| 441 | Zili Tian, Jiaorong Wu, Sicheng Wang and Chi Zhao | Co-design of traditional and demand-responsive transit based on existing stops | P1 |
| 442 | Lanhang Ye, Toshiyuki Yamamoto, Takayuki Anamoto, Kazuyuki Umiguchi and Takayuki Morikawa | INTEGRATING PERSONAL RAPID TRANSIT SYSTEM AT SIGNALIZED INTERSECTIONS: DESIGNING, SIMULATION, AND IMPLICATION | P1 |
| 443 | Lanhang Ye and Toshiyuki Yamamoto | MODULAR AUTONOMOUS VEHICLE IN HETEROGENEOUS TRAFFIC FLOW: MODELING, SIMULATION, AND IMPLICATION | P2 |
| 444 | Feng Xiao, Renbin Pan, Lu Li, Hegui Zhang and Minyu Shen | A NOVEL METHOD FOR TRAFFIC STATE ESTIMATION IN UNMONITORED NETWORK LOCATIONS | P8 |
| 445 | Zhongxiang Feng, Ya Gao, Dianchen Zhu and Bin Zhou | IMPACT OF RISK PERCEPTION AND TRUST IN AUTONOMOUS VEHICLES ON PEDESTRIAN CROSSING DECISION: NAVIGATING THE SOCIAL-TECHNOLOGICAL INTERSECTION WITH THE ICLV MODEL | E6 |
| 446 | Zerui Zhao, Jianming Ling, Fan Yang, Jiake Zhang and Zhongxu Guo | EVALUATION METHOD FOR VOIDS BENEATH AIRFIELD RIGID PAVEMENT SLABS BASED ON STRAIN SENSING | P5 |
| 447 | Yuzheng Guo, Jichen Zhu, Yuqi Shi and Xiaoguang Yang | AN INTEGRATED LANE WIDTH DESIGN METHOD CONSIDERING THE DEDICATED LANE FOR ELECTRIC BICYCLES | P3 |
| 448 | Manman Zhu and N.N. Sze | EFFECTS OF WEATHER CONDITIONS ON PEDESTRIAN CROSSING RISK PERCEPTION AT MIDBLOCK: A CAVE-BASED SIMULATOR STUDY | P8 |

| | | | |
|---|---|---|---|
| 449 | Junze Yang and Xiangdong Xu | MODELING THE UNCERTAINTIES FROM DATA IMPERFECTION AND TASTE HETEROGENEITY IN LINK-BASED ROUTE CHOICE ANALYSIS VIA BAYESIAN VARIATIONAL INVERSE REINFORCEMENT LEARNING (BVIRL) | P3 |
| 450 | Shicheng Zhao and Xiangdong Xu | ASSESSING THE IMPACT OF A CIRCLE LINE ON THE RESILIENCE OF THE SHANGHAI METRO NETWORK | P8 |
| 451 | Zijian Wang, Kai Qu, Xiangdong Xu, Chao Yang, Li Guo and Jiaqi Hu | ESTIMATING INTERCITY RAILWAY TRAVEL DEMAND OF A MEGA-CITY REGION: A HYBRID MULTI-SOURCE DATA-DRIVEN AND MODEL-DRIVEN APPROACH | F2 |
| 452 | Mengyao Yang and Jasmine Siu Lee Lam | Ripple Effect of Ammonia Supply Disruption on the Ammonia Bunker Supply Chain | F4 |
| 453 | Kenan Zhang, Javier Alonso-Mora and Andres Fielbaum | WHAT DO WALKING AND E-HAILING BRING TO SCALE ECONOMIES IN ON-DEMAND MOBILITY? | F3 |
| 454 | John Thøgersen and Ting Zhang | CONSUMER ENGAGEMENT AND THE ADOPTION OF EMERGING SUSTAINABLE TRANSPORT OPTIONS IN CHINA AND DENMARK | F3 |
| 455 | Yunxiang SHU, Zhongyi JIN, Chenliang ZHANG, Kam K.H. NG | Optimising Last-Mile Delivery Network: Locker-Drone Logistics System Design under Uncertain Demand | P7 |
| 456 | J. CARPIO | Automated Energy-Efficient Adjustment of Adaptive Cruise Control Speed Setting Using Near Real-Time Downstream Vehicle Trajectory Data | P4 |
| 482 | Zheng Xu, Nan Zheng | Investigating perception, critical scenarios and training gaps for autonomous driving systems – a human intervention perspective | E6 |

# Five Most Related Papers

| Paper ID | Five most related paper IDs | | | | |
|---|---|---|---|---|---|
| 5 | 337 | 348 | 332 | 29 | 120 |
| 7 | 303 | 335 | 365 | 121 | 344 |
| 13 | 333 | 413 | 66 | 126 | 254 |
| 14 | 17 | 203 | 303 | 316 | 102 |
| 15 | 364 | 265 | 62 | 182 | 184 |
| 17 | 14 | 264 | 229 | 49 | 423 |
| 18 | 89 | 254 | 83 | 178 | 211 |
| 19 | 89 | 178 | 428 | 90 | 254 |
| 20 | 250 | 135 | 156 | 395 | 101 |
| 21 | 333 | 304 | 102 | 178 | 115 |
| 23 | 28 | 147 | 370 | 192 | 411 |
| 25 | 288 | 21 | 102 | 349 | 57 |
| 26 | 147 | 178 | 64 | 370 | 189 |
| 27 | 127 | 157 | 108 | 336 | 262 |
| 28 | 370 | 23 | 147 | 174 | 192 |
| 29 | 333 | 163 | 102 | 208 | 21 |
| 30 | 62 | 265 | 83 | 37 | 208 |
| 31 | 236 | 139 | 302 | 29 | 77 |
| 32 | 417 | 139 | 121 | 240 | 268 |
| 33 | 455 | 134 | 121 | 116 | 322 |
| 35 | 384 | 72 | 247 | 275 | 331 |
| 36 | 362 | 211 | 382 | 231 | 51 |
| 37 | 60 | 443 | 118 | 122 | 445 |
| 39 | 309 | 448 | 445 | 356 | 93 |
| 40 | 350 | 20 | 421 | 178 | 21 |
| 41 | 265 | 256 | 62 | 127 | 444 |
| 42 | 212 | 45 | 78 | 443 | 118 |
| 44 | 94 | 100 | 393 | 285 | 384 |
| 45 | 78 | 196 | 342 | 42 | 291 |
| 46 | 397 | 254 | 178 | 350 | 288 |
| 48 | 234 | 49 | 109 | 307 | 296 |
| 49 | 48 | 442 | 140 | 204 | 229 |
| 51 | 454 | 254 | 362 | 211 | 397 |
| 54 | 82 | 415 | 98 | 118 | 102 |
| 55 | 218 | 5 | 348 | 454 | 83 |
| 56 | 234 | 374 | 307 | 274 | 258 |
| 57 | 333 | 178 | 13 | 66 | 288 |
| 58 | 358 | 344 | 98 | 147 | 330 |
| 60 | 78 | 37 | 416 | 212 | 291 |
| 62 | 156 | 118 | 265 | 182 | 30 |
| 63 | 196 | 342 | 90 | 157 | 115 |
| 64 | 66 | 281 | 333 | 178 | 26 |
| 65 | 446 | 99 | 434 | 415 | 108 |
| 66 | 64 | 333 | 178 | 13 | 441 |
| 67 | 148 | 108 | 256 | 87 | 157 |

| | | | | | |
|---|---|---|---|---|---|
| 68 | 355 | 287 | 444 | 127 | 265 |
| 69 | 215 | 170 | 225 | 72 | 437 |
| 70 | 153 | 37 | 30 | 442 | 122 |
| 72 | 131 | 275 | 247 | 384 | 340 |
| 73 | 203 | 216 | 125 | 104 | 342 |
| 75 | 333 | 170 | 66 | 29 | 115 |
| 76 | 330 | 146 | 268 | 92 | 218 |
| 77 | 236 | 139 | 337 | 29 | 137 |
| 78 | 212 | 45 | 42 | 342 | 246 |
| 79 | 239 | 411 | 134 | 384 | 247 |
| 81 | 451 | 304 | 335 | 365 | 277 |
| 82 | 54 | 121 | 134 | 415 | 98 |
| 83 | 30 | 319 | 211 | 229 | 204 |
| 84 | 347 | 424 | 78 | 45 | 212 |
| 87 | 157 | 108 | 364 | 262 | 67 |
| 88 | 113 | 222 | 280 | 157 | 251 |
| 89 | 254 | 18 | 19 | 428 | 395 |
| 90 | 196 | 97 | 63 | 157 | 27 |
| 91 | 118 | 82 | 122 | 415 | 187 |
| 92 | 433 | 410 | 268 | 115 | 303 |
| 93 | 448 | 445 | 383 | 438 | 374 |
| 94 | 97 | 239 | 393 | 251 | 384 |
| 96 | 387 | 444 | 127 | 68 | 396 |
| 97 | 316 | 353 | 447 | 238 | 94 |
| 98 | 82 | 54 | 170 | 455 | 97 |
| 99 | 96 | 396 | 187 | 265 | 67 |
| 100 | 339 | 285 | 394 | 393 | 450 |
| 101 | 288 | 178 | 250 | 21 | 20 |
| 102 | 21 | 170 | 54 | 353 | 333 |
| 103 | 118 | 45 | 136 | 130 | 196 |
| 104 | 216 | 125 | 73 | 203 | 437 |
| 105 | 445 | 373 | 348 | 104 | 342 |
| 108 | 157 | 130 | 444 | 118 | 87 |
| 109 | 307 | 274 | 374 | 48 | 234 |
| 111 | 366 | 21 | 115 | 281 | 29 |
| 113 | 72 | 247 | 411 | 331 | 275 |
| 114 | 443 | 342 | 226 | 78 | 196 |
| 115 | 366 | 365 | 335 | 178 | 304 |
| 116 | 33 | 121 | 322 | 293 | 455 |
| 118 | 130 | 353 | 122 | 42 | 91 |
| 119 | 380 | 21 | 66 | 333 | 13 |
| 120 | 139 | 337 | 268 | 164 | 126 |
| 121 | 455 | 33 | 116 | 82 | 322 |
| 122 | 118 | 42 | 187 | 91 | 212 |
| 124 | 209 | 72 | 15 | 254 | 433 |
| 125 | 216 | 73 | 203 | 104 | 413 |
| 126 | 13 | 333 | 120 | 29 | 289 |
| 127 | 444 | 265 | 108 | 68 | 118 |

| | | | | | |
|---|---|---|---|---|---|
| 129 | 174 | 115 | 410 | 239 | 331 |
| 130 | 118 | 353 | 444 | 108 | 136 |
| 131 | 194 | 72 | 275 | 247 | 289 |
| 132 | 169 | 178 | 447 | 307 | 428 |
| 134 | 411 | 33 | 82 | 121 | 237 |
| 135 | 250 | 20 | 288 | 421 | 21 |
| 136 | 353 | 118 | 130 | 363 | 442 |
| 137 | 287 | 118 | 54 | 42 | 75 |
| 138 | 425 | 342 | 265 | 41 | 234 |
| 139 | 120 | 268 | 77 | 29 | 236 |
| 140 | 265 | 182 | 49 | 130 | 444 |
| 143 | 237 | 411 | 331 | 275 | 72 |
| 144 | 29 | 236 | 111 | 163 | 120 |
| 145 | 208 | 305 | 444 | 425 | 182 |
| 146 | 268 | 121 | 98 | 218 | 335 |
| 147 | 23 | 370 | 28 | 178 | 26 |
| 148 | 153 | 67 | 157 | 108 | 184 |
| 150 | 182 | 449 | 41 | 98 | 62 |
| 153 | 148 | 97 | 184 | 70 | 157 |
| 156 | 62 | 277 | 21 | 20 | 208 |
| 157 | 87 | 108 | 148 | 364 | 262 |
| 158 | 164 | 120 | 102 | 29 | 187 |
| 163 | 333 | 29 | 178 | 21 | 289 |
| 164 | 158 | 120 | 208 | 139 | 29 |
| 169 | 132 | 178 | 395 | 147 | 250 |
| 170 | 413 | 225 | 411 | 102 | 289 |
| 174 | 28 | 331 | 370 | 410 | 413 |
| 178 | 316 | 147 | 66 | 21 | 115 |
| 182 | 150 | 108 | 444 | 62 | 265 |
| 184 | 364 | 148 | 118 | 127 | 153 |
| 187 | 416 | 122 | 212 | 78 | 342 |
| 188 | 383 | 93 | 445 | 448 | 109 |
| 189 | 26 | 178 | 251 | 147 | 342 |
| 192 | 23 | 28 | 147 | 370 | 178 |
| 194 | 131 | 72 | 340 | 411 | 247 |
| 195 | 360 | 329 | 62 | 54 | 335 |
| 196 | 342 | 45 | 443 | 78 | 203 |
| 198 | 207 | 441 | 5 | 348 | 352 |
| 203 | 73 | 216 | 196 | 125 | 342 |
| 204 | 254 | 13 | 333 | 49 | 350 |
| 205 | 307 | 182 | 97 | 18 | 147 |
| 207 | 198 | 254 | 13 | 413 | 101 |
| 208 | 302 | 29 | 164 | 145 | 62 |
| 209 | 254 | 350 | 449 | 72 | 124 |
| 211 | 362 | 83 | 438 | 13 | 51 |
| 212 | 42 | 78 | 347 | 424 | 246 |
| 213 | 450 | 288 | 342 | 316 | 364 |
| 215 | 69 | 384 | 437 | 247 | 170 |

| | | | | | |
|---|---|---|---|---|---|
| 216 | 125 | 73 | 203 | 104 | 443 |
| 218 | 384 | 247 | 55 | 410 | 413 |
| 219 | 336 | 280 | 157 | 27 | 98 |
| 222 | 157 | 364 | 305 | 87 | 88 |
| 225 | 413 | 170 | 411 | 69 | 327 |
| 226 | 102 | 114 | 443 | 21 | 304 |
| 229 | 451 | 178 | 21 | 156 | 83 |
| 230 | 280 | 251 | 222 | 63 | 364 |
| 231 | 354 | 430 | 209 | 362 | 51 |
| 232 | 333 | 335 | 365 | 240 | 289 |
| 234 | 48 | 127 | 122 | 307 | 374 |
| 236 | 77 | 139 | 163 | 144 | 31 |
| 237 | 411 | 331 | 289 | 143 | 134 |
| 238 | 97 | 196 | 163 | 415 | 118 |
| 239 | 253 | 79 | 94 | 384 | 75 |
| 240 | 268 | 455 | 232 | 417 | 29 |
| 245 | 280 | 27 | 336 | 108 | 449 |
| 246 | 78 | 342 | 212 | 42 | 347 |
| 247 | 384 | 275 | 72 | 411 | 331 |
| 250 | 288 | 135 | 20 | 450 | 421 |
| 251 | 280 | 189 | 307 | 27 | 94 |
| 253 | 239 | 384 | 94 | 63 | 247 |
| 254 | 350 | 207 | 204 | 13 | 209 |
| 256 | 41 | 68 | 148 | 67 | 108 |
| 257 | 108 | 364 | 157 | 196 | 87 |
| 258 | 257 | 157 | 234 | 67 | 251 |
| 262 | 108 | 130 | 444 | 157 | 87 |
| 264 | 229 | 19 | 442 | 49 | 100 |
| 265 | 444 | 127 | 62 | 41 | 15 |
| 268 | 240 | 139 | 120 | 115 | 289 |
| 274 | 374 | 307 | 109 | 309 | 438 |
| 275 | 331 | 247 | 72 | 289 | 340 |
| 277 | 156 | 21 | 62 | 304 | 431 |
| 279 | 382 | 374 | 307 | 60 | 67 |
| 280 | 336 | 230 | 203 | 157 | 251 |
| 281 | 64 | 66 | 111 | 21 | 333 |
| 285 | 393 | 339 | 394 | 100 | 44 |
| 287 | 137 | 298 | 68 | 118 | 355 |
| 288 | 250 | 450 | 135 | 101 | 25 |
| 289 | 275 | 237 | 331 | 411 | 131 |
| 291 | 42 | 78 | 45 | 246 | 212 |
| 293 | 121 | 116 | 322 | 33 | 348 |
| 296 | 122 | 347 | 37 | 103 | 291 |
| 298 | 287 | 445 | 137 | 68 | 348 |
| 302 | 208 | 164 | 158 | 139 | 120 |
| 303 | 7 | 335 | 365 | 232 | 329 |
| 304 | 344 | 365 | 366 | 21 | 335 |
| 305 | 222 | 145 | 87 | 364 | 209 |

| | | | | | |
|---|---|---|---|---|---|
| 307 | 374 | 274 | 109 | 438 | 93 |
| 309 | 39 | 354 | 374 | 109 | 234 |
| 316 | 178 | 97 | 21 | 66 | 102 |
| 317 | 433 | 303 | 329 | 63 | 138 |
| 319 | 83 | 30 | 350 | 72 | 204 |
| 322 | 116 | 121 | 293 | 134 | 33 |
| 325 | 358 | 163 | 136 | 411 | 333 |
| 327 | 225 | 413 | 170 | 72 | 348 |
| 329 | 335 | 303 | 29 | 344 | 333 |
| 330 | 121 | 33 | 455 | 240 | 98 |
| 331 | 275 | 237 | 174 | 411 | 340 |
| 332 | 5 | 111 | 337 | 139 | 366 |
| 333 | 13 | 66 | 21 | 232 | 29 |
| 335 | 365 | 303 | 304 | 115 | 232 |
| 336 | 29 | 280 | 27 | 203 | 289 |
| 337 | 120 | 29 | 139 | 5 | 126 |
| 339 | 100 | 285 | 250 | 21 | 393 |
| 340 | 275 | 331 | 411 | 72 | 131 |
| 342 | 196 | 45 | 443 | 78 | 246 |
| 344 | 304 | 365 | 366 | 335 | 21 |
| 347 | 84 | 212 | 246 | 424 | 78 |
| 348 | 449 | 342 | 350 | 445 | 443 |
| 349 | 134 | 25 | 116 | 102 | 33 |
| 350 | 254 | 421 | 449 | 209 | 431 |
| 352 | 441 | 163 | 442 | 348 | 333 |
| 353 | 118 | 130 | 136 | 363 | 102 |
| 354 | 231 | 430 | 309 | 350 | 250 |
| 355 | 68 | 62 | 265 | 287 | 444 |
| 356 | 296 | 37 | 39 | 482 | 122 |
| 358 | 325 | 58 | 121 | 411 | 415 |
| 359 | 5 | 366 | 285 | 49 | 348 |
| 360 | 329 | 195 | 303 | 335 | 14 |
| 362 | 211 | 13 | 83 | 436 | 409 |
| 363 | 353 | 136 | 118 | 130 | 103 |
| 364 | 108 | 15 | 157 | 87 | 184 |
| 365 | 304 | 344 | 366 | 335 | 115 |
| 366 | 304 | 365 | 344 | 115 | 111 |
| 367 | 296 | 234 | 347 | 307 | 396 |
| 370 | 28 | 23 | 147 | 174 | 331 |
| 373 | 105 | 445 | 348 | 342 | 104 |
| 374 | 307 | 274 | 109 | 279 | 93 |
| 379 | 178 | 147 | 169 | 254 | 366 |
| 380 | 119 | 62 | 225 | 413 | 66 |
| 382 | 279 | 309 | 374 | 307 | 39 |
| 383 | 93 | 188 | 445 | 397 | 374 |
| 384 | 247 | 35 | 72 | 275 | 215 |
| 385 | 116 | 49 | 342 | 442 | 91 |
| 387 | 396 | 96 | 187 | 482 | 416 |

| | | | | | |
|---|---|---|---|---|---|
| 393 | 394 | 285 | 94 | 339 | 100 |
| 394 | 393 | 285 | 100 | 339 | 204 |
| 395 | 169 | 20 | 421 | 350 | 178 |
| 396 | 387 | 96 | 122 | 127 | 416 |
| 397 | 46 | 383 | 436 | 454 | 254 |
| 403 | 452 | 410 | 215 | 331 | 384 |
| 409 | 362 | 19 | 354 | 395 | 254 |
| 410 | 174 | 331 | 403 | 72 | 129 |
| 411 | 134 | 237 | 413 | 143 | 275 |
| 413 | 170 | 225 | 13 | 411 | 28 |
| 415 | 54 | 82 | 118 | 91 | 108 |
| 416 | 187 | 60 | 78 | 122 | 91 |
| 417 | 32 | 240 | 232 | 289 | 121 |
| 421 | 350 | 250 | 135 | 288 | 20 |
| 423 | 304 | 303 | 335 | 7 | 366 |
| 424 | 84 | 212 | 78 | 347 | 42 |
| 425 | 415 | 96 | 208 | 41 | 444 |
| 428 | 19 | 89 | 169 | 132 | 90 |
| 430 | 354 | 231 | 362 | 384 | 437 |
| 431 | 350 | 277 | 333 | 254 | 49 |
| 432 | 72 | 384 | 454 | 247 | 331 |
| 433 | 317 | 115 | 92 | 303 | 63 |
| 434 | 265 | 148 | 444 | 130 | 62 |
| 436 | 397 | 437 | 362 | 51 | 83 |
| 437 | 454 | 215 | 384 | 69 | 104 |
| 438 | 448 | 307 | 445 | 93 | 383 |
| 440 | 28 | 447 | 147 | 23 | 437 |
| 441 | 66 | 352 | 64 | 333 | 13 |
| 442 | 136 | 342 | 246 | 443 | 66 |
| 443 | 114 | 342 | 42 | 196 | 78 |
| 444 | 265 | 130 | 108 | 127 | 68 |
| 445 | 448 | 105 | 291 | 93 | 37 |
| 446 | 65 | 434 | 329 | 347 | 444 |
| 447 | 28 | 147 | 97 | 23 | 178 |
| 448 | 445 | 93 | 438 | 307 | 39 |
| 449 | 350 | 348 | 30 | 209 | 150 |
| 450 | 288 | 250 | 213 | 135 | 178 |
| 451 | 364 | 304 | 229 | 335 | 15 |
| 452 | 403 | 138 | 410 | 184 | 79 |
| 453 | 163 | 289 | 120 | 348 | 126 |
| 454 | 437 | 384 | 432 | 51 | 72 |
| 455 | 121 | 33 | 134 | 240 | 116 |
| 456 | 122 | 78 | 84 | 118 | 42 |
| 482 | 445 | 105 | 347 | 396 | 387 |