INSTR2023: THE 9TH INTERNATIONAL SYMPOSIUM ON TRANSPORT NETWORK RESILIENCE

Edited by: Prof. W.Y. Szeto, Dr. Jintao Ke and Dr. Ryan C.P. Wong

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INSTITUTE OF TRANSPORT STUDIES
交通運輸研究所

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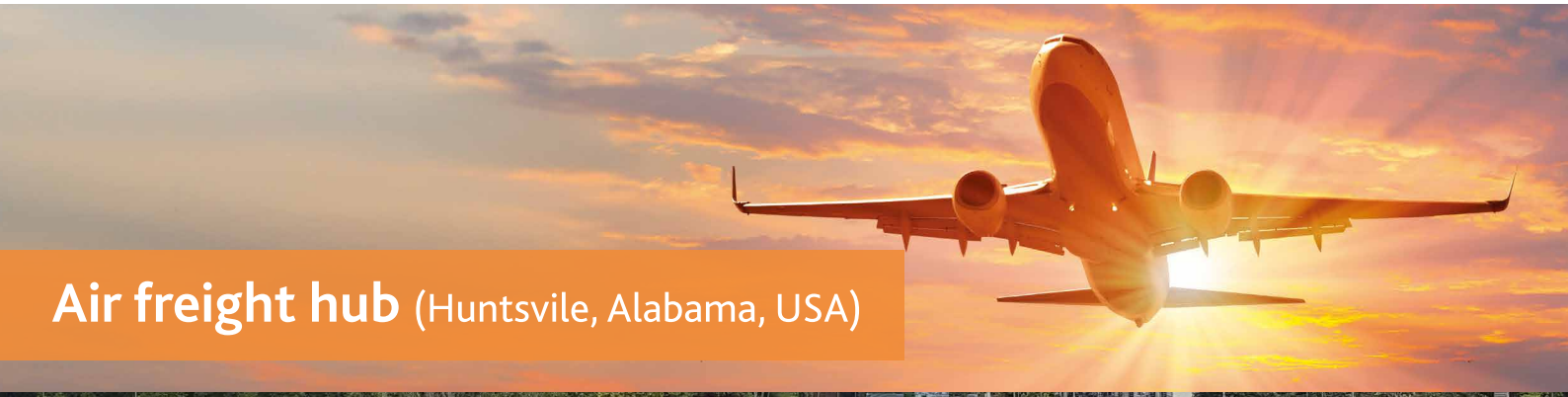

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Message from the Local Organizing Co-Chairs

Prof. W.Y. SZETO

Dr. Jintao KE

Dr. Ryan C.P. WONG

It is our great honor and pleasure to welcome you to INSTR2023: The 9th International Symposium on Transport Network Resilience, co-organized by the Institute of Transport Studies and Department of Civil Engineering at The University of Hong Kong. INSTR started from its first symposium in 2001, and it has grown into a major international event and attracted hundreds of participants from the government, industry and academia sectors.

This symposium has drawn numerous abstract submissions from researchers from all over the world. After the review and selection process, a total of 88 papers have been accepted for presentation at the symposium. We would like to make use of this opportunity to thank all authors who have contributed excellent papers to our symposium, covering a broad spectrum of topics related to transport network resilience and reliability.

We are honored to have Ir. Prof. Sai-hung LAM, the Secretary for Transport and Logistics, the Hong Kong SAR Government, as our Officiating Guest of Honor. We are also honored that Prof. Hani MAHMASSANI from Northwestern University, Prof. Yu-Chiun CHIOU from National Yang Ming Chiao Tung University, Prof. Fumitaka KURAUCHI from Gifu University, and Emeritus Prof. William H.K. LAM from The Hong Kong Polytechnic University have kindly accepted our invitation to be Keynote Speakers and share their knowledge, insights, and inspirations with us.

Our sincere gratitude also goes to our financial sponsors, Kerry Logistics and MTR Corporation for their generous support as well as our non-financial sponsors, the Chartered Institute of Logistics and Transport in Hong Kong, the Chartered Institution of Highways & Transportation (Hong Kong), the Hong Kong Institution of Engineers (Logistics and Transportation Division), the Hong Kong Institution of Highways and Transportation, and the Hong Kong Society for Transportation Studies. Last but not least, we would like to thank the Local Organizing Committee members, the International Scientific Committee members, and especially the Symposium Secretary, Ms. Ruby Kwok, for their assistance in putting together this symposium.

On behalf of the Local Organizing Committee, we hope that you will find this symposium stimulating, rewarding, and enjoyable. We also sincerely hope that you will continue to support our symposium and academic activities in the future. Thank you.

Prof. W.Y. Szeto Dr. Jintao Ke Dr. Ryan C.P. Wong

Co-chairs
Local Organizing Committee
INSTR2023: The 9th International Symposium on Transport Network Resilience

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Overview Schedule

Day 1: 13 December 2023 (Wednesday)

Time	Event				
08:20 – 09:00	**Registration** (Pre-Function Area)				
09:00 – 09:25	**Opening Session** (Picasso Room)				
	Prof. Wai Yuen SZETO Co-chair, INSTR2023: The 9th International Symposium on Transport Network Resilience				
	Ir. Prof. Sai-Hung LAM The Secretary for Transport and Logistics, The Hong Kong SAR Government				
09:25 – 09:35	**Group Photo Taking** (Picasso Room)				
09:35 – 10:05	**Keynote Session** (Picasso Room) (Moderator: Dr. Ryan C.P. WONG)				
	Keynote speech by Prof. Hani MAHMASSANI William A. Patterson Distinguished Chair in Transportation, Northwestern University Title: Enhancing transportation system resilience through technology: Lessons from the pandemic				
10:05 – 10:35	**Keynote speech by Prof. Yu-Chiun CHIOU** Professor, Department of Transportation and Logistics Management, National Yang Ming Chiao Tung University Title: Driver scheduling models under stochastic travel times				
10:35 – 11:00	**Coffee Break** (outside the conference rooms)				
11:00 – 12:00	**Keynote Session** (Picasso Room) (Moderator: Dr. Ryan C.P. WONG)				
	Keynote speech by Prof. Fumitaka KURAUCHI Professor, Department of Civil Engineering, Gifu University Title: Vulnerability assessment of transportation and power networks considering interdependent structures				
	Keynote speech by Prof. William H.K. LAM Emeritus Professor, Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University Title: A reliability-based path-finding algorithm with consideration of travel time and energy consumption uncertainties				
12:00 – 13:30	**Symposium Lunch** (Opera Room, B3 Level)				
13:30 – 15:00	**Session A1** *(Picasso Room)* *Transportation Network Reliability I*	**Session A2** *(Monet Room A)* *Evacuation and Disaster Relief I*	**Session A3** *(Monet Room B)* *COVID-19 and Epidemics*	**Session A4** *(Picasso Room A)* *Logistics and Supply Chain I*	**Session A5** *(Picasso Room B)* *Travel Behavior I*
15:00 – 15:30	**Coffee Break** (outside the conference rooms)				
15:30 – 17:00	**Session B1** *(Picasso Room)* *Travel Behavior II*	**Session B2** *(Monet Room A)* *Network Vulnerability and Reliability*	**Session B3** *(Monet Room B)* *Public Transportation I*	**Session B4** *(Picasso Room A)* *Transportation Network Recovery*	**Session B5** *(Picasso Room B)* *Stochastic Traffic Signal Control*
18:00 – 20:00	**Symposium Banquet** (Tsim Tung Ho Choi Seafood Restaurant)				

Overview Schedule

Day 2: 14 December 2023 (Thursday)

Time	Event				
08:20 – 09:00	**Registration** (Pre-Function Area)				
09:00 – 10:30	**Session C1** *(Picasso Room) Traffic Flow and Control*	**Session C2** *(Monet Room A) Autonomous Vehicles*	**Session C3** *(Monet Room B) Transport Resilience*	**Session C4** *(Picasso Room A) Big Data and Transportation*	**Session C5** *(Picasso Room B) Public Transportation II*
10:30 – 10:50	**Coffee Break** (outside the conference rooms)				
10:50 – 12:20	**Session D1** *(Picasso Room) Transportation Network Resilience I*	**Session D2** *(Monet Room A) Shared Mobility*	**Session D3** *(Monet Room B) Logistics and Supply Chain II*	**International Scientific Committee Meeting** *(Picasso Room A)*	**Session D4** *(Picasso Room B) Bus Operations*
12:20 – 13:20	**Symposium Lunch** (Opera Room, B3 Level)				
13:20 – 14:50	**Session E1** *(Picasso Room) Evacuation and Disaster Relief II*	**Session E2** *(Monet Room A) Rail System Vulnerability*	**Session E3** *(Monet Room B) Transportation Network Resilience II*	**Session E4** *(Picasso Room A) Pricing and Reward*	**Session E5** *(Picasso Room B) Transport Planning and System Design*
14:50 – 15:10	**Coffee Break** (outside the conference rooms)				
15:10 – 16:40	**Session F1** *(Picasso Room) Rail Transportation*	**Session F2** *(Monet Room A) Network Resilience and Recovery*	**Session F3** *(Monet Room B) Traffic Prediction*	**Session F4** *(Picasso Room A) Connected Vehicles and Traffic Assignment*	**Session F5** *(Picasso Room B) Transportation Network Reliability II*
16:40 – 17:00	**Closing Session** (Picasso Room)				
	Prof. Michael G.H. BELL Convenor, The International Symposium on Transport Network Resilience				
	Dr. Jintao KE Co-chair, INSTR2023: The 9th International Symposium on Transport Network Resilience				
	Prof. Nour-Eddin EL FAOUZI and Dr. Angelo FURNO Co-chairs, INSTR2026: The 10th International Symposium on Transport Network Resilience				

Detailed Presentation Schedule

Day 1: 13 December 2023 (Wednesday)

Session A1: Transportation Network Reliability I
Session Chair: Dr. Y.H. KUO (Picasso Room)

13:30 – 15:00	**RELIABILITY IMPROVEMENT WITH PARKING RESERVATION SERVICE CONSIDERING PARKING UNCERTAINTY** Xiaoyun WANG, Meng XU, and Haohan XIAO
	THE OPTIMAL LINK ESTABLISHMENT PROBLEM FOR ENHANCING NETWORK CONNECTIVITY RELIABILITY UNDER MULTIPLE SCENARIO DISASTERS H. ANDO, F. KURAUCHI, and S. SUGIURA
	IMPACT OF URBAN MORPHOLOGY ON THE RELIABILITY OF ELECTRIC ON-DEMAND FEEDER SERVICES Yumeng FANG, Haruko NAKAO, Richard CONNORS, Tai-Yu MA, and Francesco VITI

Session A2: Evacuation and Disaster Relief I
Session Chair: Dr. Jacqueline LO (Monet Room A)

13:30 – 15:00	**HOW DOES THE PROPORTION OF CHILDREN IN NEED AFFECT EVACUATION EFFICIENCY?** Hongliu LI and Jacqueline LO
	EVACUATION ANALYSIS OF SUDDEN LARGE PASSENGER FLOW IN URBAN RAIL TRANSIT HUB: A CASE OF BEJING SOUTH RAILWAY STATION Wenhui ZHAO and Meng XU
	URBAN MULTI-MODAL TRANSPORTATION NETWORK RECOVERY STRATEGIES FROM A RESILIENCE PERSPECTIVE Siyu CHEN, Jie LI, and Mengjia ZHANG

Session A3: COVID-19 and Epidemics
Session Chair: Dr. Wei LIU (Monet Room B)

13:30 – 15:00	**HOW AIR TRANSPORT NETWORKS RESPOND TO LONG-LASTING DISRUPTIVE EVENTS LIKE COVID-19: THE FIRST STEP TOWARD LONG-TERM RESILIENCE** Siping LI and Yaoming ZHOU
	VARIANT PATTERNS AND INFLUENCE OF INTER-REGIONAL TRAVEL DURING THE SARS-COV-2 EXPANSION IN SOUTH AFRICA Weiyu LUO, Xin WU, and Chenfeng XIONG
	EVALUATING TRAVEL BEHAVIOR RESILIENCE ACROSS METROPOLITAN AND RURAL AREAS DURING THE COVID-19 PANDEMIC: CONTRIBUTIONS OF VACCINATION AND EPIDEMIOLOGICAL INDICATORS Haoning XI, John D. NELSON, David A. HENSHER, and Songhua HU

The presenter(s) of each paper is underlined.

Detailed Presentation Schedule

Day 1: 13 December 2023 (Wednesday)

Session A4: Logistics and Supply Chain I
Session Chair: Prof. Anthony CHEN (Picasso Room A)

13:30 – 15:00	**APPLYING PAGERANK FOR DETECTING CRITICAL NODES IN ROAD FREIGHT TRANSPORTATION NETWORK** M.A. KHAN, G. GRANDE, B. MEHRAN, and J.D. REGEHR
	STOCHASTIC SERVICE NETWORK DESIGN FOR BUS-INTEGRATED FREIGHT TRANSPORT SYSTEMS Jie LIN and Fangni ZHANG
	ANALYSIS OF CONTAINER SHIPPING SCHEDULE STABILITY Michael G.H. BELL, W. ZE, S. ZHU, and K.F. CHEUNG

Session A5: Travel Behavior I
Session Chair: Prof. Becky P.Y. LOO (Picasso Room B)

13:30 – 15:00	**MEASURING CRASH-INDUCED TRAVEL DELAYS: AN APPROACH USING GPS DATA** Ting LIAN and Becky P.Y. LOO
	HOW DO PEOPLE VALUE RELIABLE MODES IN THEIR TRANSIT PATH CHOICES? Kwangho BAEK and Alireza KHANI
	ASSESSING THE RELIABILITY OF ROUTE CHOICE SETS: CONSIDERING THE SIMILARITY BETWEEN ALTERNATIVES H. WANG, E. MOYLAN, and D. LEVINSON

The presenter(s) of each paper is underlined.

Detailed Presentation Schedule

Day 1: 13 December 2023 (Wednesday)

Session B1: Travel Behavior II
Session Chair: Dr. Sunghoon JANG (Picasso Room)

15:30 – 17:00	**MODELING ROUTE CHOICE BEHAVIOR CONSIDERING DRIVERS' INFORMATION ACQUISITION PROCESS** Yuki ARAI and Daisuke FUKUDA
	MODELLING ROUTE CHOICE BEHAVIOR UNDER RISKY TRAVEL TIME: A REGRETBASED APPROACH WITH MULTIPLICATIVE ERRORS Sunghoon JANG and Anthony CHEN
	EMPIRICAL ANALYSIS OF ROUTE CHOICE BEHAVIOR UNDER TRAFFIC RESTRICTIONS DUE TO RECONSTRUCTION WORKS OF URBAN EXPRESSWAY H. ANDO, Y. ASAKURA, S. NAKAGAWA, and T. MARUYAMA

Session B2: Network Vulnerability and Reliability
Session Chair: Prof. Kenetsu UCHIDA (Monet Room A)

15:30 – 17:00	**DISCONNECTION DURATION TIME BETWEEN TWO NODES CONSIDERING CORRELATION AMONG LINK CLOSURES IN ROAD NETWORKS** R. TANI, K. UCHIDA, and A. SUMALEE
	CRITICAL LINK SELECTION CRITERIA IN CONGESTIBLE TRANSPORT NETWORKS M. CAVALERI, P. DELLE SITE, A. DONNO, and S. GHOSLYA
	ANALYZING TRANSPORTATION NETWORK VULNERABILITY TO CRITICAL-LINK ATTACKS THROUGH TOPOLOGY CHANGES AND TRAFFIC VOLUME ASSESSMENT L.D.C.H.N. KALPANA, Teppei KATO, and Kazushi SANO

Session B3: Public Transportation I
Session Chair: Prof. S.C. WONG (Monet Room B)

15:30 – 17:00	**ROBUST INTEGRATED PLANNING ON EN-ROUTE CHARGER DEPLOYMENT AND CHARGING SCHEDULING FOR URBAN ELECTRIC BUS SYSTEMS** Yu ZHOU and Yun WANG
	KNOWLEDGE GRAPH OF URBAN RAIL TRANSIT OPERATION INCIDENTS: CONSTRUCTION AND APPLICATIONS Rui MA, Sanghuiyu YAN, and Jian LI
	ADAPTIVE SCHEDULING OF ELECTRIC BUS SERVICES WITH STOP-SKIPPING PATTERN USING A REINFORCEMENT LEARNING APPROACH Guang-Yu LI, Andy H.F. CHOW, and Cheng-Shuo YING

The presenter(s) of each paper is underlined.

Detailed Presentation Schedule

Day 1: 13 December 2023 (Wednesday)

Session B4: Transportation Network Recovery
Session Chair: Prof. Yu JIANG (Picasso Room A)

15:30 – 17:00	**RESILIENCE OPTIMAL-ORIENTED RESTORATION SCHEDULING OPTIMISATION FOR DISRUPTED TRANSPORTATION NETWORKS** Y. JIANG, C.M. JIANG, S.P. ZHONG, and J.Y. MIN
	SURROGATE MODELING FOR RECOVERY MEASURES OPTIMIZATION TO IMPROVE TRAFFIC RESILIENCE Q.L. LU, W. SUN, J. DAI, Jan-Dirk SCHMÖCKER, and C. ANTONIOU
	INFERRING NETWORK CAPACITY REDUCTION AND DEMAND VARIATION AFTER DISRUPTIONS FOR RAPID SYSTEM EVALUATION S. Travis WALLER, Qingying HE, and Wei LIU

Session B5: Stochastic Traffic Signal Control
Session Chair: Prof. Hong K. LO (Picasso Room B)

15:30 – 17:00	**COORDINATED SIGNAL CONTROL UNDER STOCHASTIC TRAFFIC DEMANDS AND TURNING RATIOS CONSIDERING SPATIAL-TEMPORAL DEPENDENCIES** Lijuan WAN and Hong K. LO
	STOCHASTIC PRIORITY-INTEGRATED COORDINATION FOR ARTERIAL SIGNAL CONTROL CONSIDERING UNCERTAINTY IN CONNECTED BUS OPERATION Shiqi OU, Kun AN, Wanjing MA, Andreas HEGYI, and Bart VAN AREM
	A REAL-TIME STOCHASTIC APPROACH TO LANE-BASED DELAY FORMULA FOR REAL-TIME ADAPTIVE SIGNAL OPERATIONS Jihye BYUN, Shin Hyoung PARK, Seunghyeon LEE, and S.C. WONG

The presenter(s) of each paper is underlined.

Detailed Presentation Schedule

Day 2: 14 December 2023 (Thursday)

Session C1: Traffic Flow and Control
Session Chair: Dr. Andy H.F. CHOW (Picasso Room)

09:00 – 10:30	**STOCHASTIC LIGHTHILL–WHITHAM–RICHARDS TRAFFIC FLOW MODEL CONSIDERING CORRELATED RANDOM PARAMETERS** Tianxiang FAN, S.C. WONG, Zhiwen ZHANG, and Jie DU
	INTELLIGENT TRAFFIC CONTROL WITH USE OF INTERNET-OF-THINGS AND REINFORCEMENT LEARNING TECHNOLOGIES Zhongyang LU, Andy H.F. CHOW, and Chunwei YANG
	INTELLIGENT INTERSECTION COORDINATION: A DYNAMIC CONTROL APPROACH FOR CONNECTED AUTONOMOUS VEHICLE TRAFFIC MANAGEMENT Chunwei YANG, Andy H.F. CHOW, and Zhongyang LU

Session C2: Autonomous Vehicles
Session Chair: Dr. Zhan ZHAO (Monet Room A)

09:00 – 10:30	**OPTIMAL DEPLOYMENT OF DEDICATED LANES FOR CONNECTED AND AUTONOMOUS VEHICLES IN MIXED URBAN TRAFFIC NETWORKS** D. NGODUY, S. LEE, C. NGUYEN, Z. ZHENG, and Hong K. LO
	TRAFFIC ASSIGNMENT MODEL FOR MIXED FLOW OF UE-PRINCIPLED HUMAN-DRIVEN VEHICLES AND SO-PRINCIPLED AUTONOMOUS VEHICLES WITH STOCHASTIC LINK CAPACITY Z. HU and T. KATO
	SHARED AUTONOMOUS VEHICLES PREFERENCE INVESTIGATION CONSIDERING RELIABILITY AND PSYCHOLOGICAL FACTORS IN A CAMPUS ENVIRONMENT Zhiwu DONG, Xiaoyu YAN, Ziyi SHI, Pengsheng CAO, Shaowen XU, Xiqun (Michael) CHEN, and Der-Horng LEE
	CUSTOMER CENTRIC & SMART RAILWAY MOBILITY H.W. CHAN, Andy K.F. PANG, and Benny K.C. NG

The presenter(s) of each paper is underlined.

Detailed Presentation Schedule

Day 2: 14 December 2023 (Thursday)

Session C3: Transport Resilience
Session Chair: Prof. Xiangdong XU (Monet Room B)

09:00 – 10:30	**ASSESSING ZONAL RESILIENCE: A STUDY ON THE IMPACT OF DAY-TO-DAY DISRUPTIONS ON THE ROAD NETWORK** Piyush LALWANI and Sai CHAND
	EVALUATING THE COMMUNITY RESILIENCE: A COMMUNITY-BASED PEER-TO-PEER RESOURCE-SHARING FRAMEWORK Zhengyang LI, Cynthia CHEN, and Anthony CHEN
	SENSITIVITY-BASED APPROACH FOR CONGESTED TRANSIT ASSIGNMENT ON SKIP-AND-STOP METRO SYSTEM Sion KIM, Donggyun KU, In-Ho LEE, Seunghyeon LEE, and Seungjae LEE

Session C4: Big Data and Transportation
Session Chair: Dr. Wei MA (Picasso Room A)

09:00 – 10:30	**TRAFFIC UNCERTAINTY PREDICTION WITH A HYBRID KALMAN FILTER BASED DEEP NEURAL NETWORK** Xinyue WU, Andy H.F. CHOW, Wei MA, William H.K. LAM, and S.C. WONG
	A DATA-DRIVEN APPROACH FOR URBAN ROAD NETWORK RESILIENCE ASSESSMENT: INTEGRATING SPATIOTEMPORAL ANALYSIS WITH RESILIENCE TRIANGLE CONCEPT Rouzbeh AZARGOSHASBI, Lina KATTAN, and Mohammad ANSARI ESFEH
	MODELLING NETWORK-WIDE TRAFFIC CONDITION ESTIMATION CONSIDERING UNCERTAINTIES AND SPARSE MULTI-TYPE DETECTORS Shao-Jie LIU, Hao FU, William H.K. LAM, and Wei MA

Session C5: Public Transportation II
Session Chair: Dr. Sujun SUN (Picasso Room B)

09:00 – 10:30	**ROBUSTNESS OF ON-DEMAND PUBLIC TRANSPORT NETWORKS FROM A RANDOM NETWORK PERSPECTIVE** Jin-Yang LI and Jing TENG
	OPTIMAL SEAT OCCUPANCY OF CUSTOMIZED BUS SERVICES CONSIDERING IN-VEHICLE INFECTION RISK COST DURING PUBLIC HEALTH EMERGENCIES S. HAO, F. DING, Y. CHEN, and S. SUN
	IMPACT OF WEATHER ON PUBLIC TRANSPORT: A STUDY OF BUS RIDERSHIP IN THE WEST MIDLANDS OF THE UK USING SMART CARD DATA Y. HUANG, Q. FU, D.J. JAROSZWESKI, and J.M. EASTON

The presenter(s) of each paper is underlined.

Detailed Presentation Schedule

Day 2: 14 December 2023 (Thursday)

Session D1: Transportation Network Resilience I
Session Chair: Dr. Fangni ZHANG (Picasso Room)

10:50 – 12:20	**A NETWORK FLOW APPROACH FOR MODELLING CONCURRENT RESTORATION PROBLEM** Yiyang PENG, Min XU, Guoyuan LI, and Anthony CHEN
	ASSESSING AND IMPROVING TRANSIT SYSTEM REDUNDANCY WITH NETWORK WIDE CAPACITY Heqing TAN, Xiangdong XU, and Anthony CHEN
	MODELING ADAPTIVE CAPACITY OF TRANSPORTATION NETWORK Yu GU and Anthony CHEN

Session D2: Shared Mobility
Session Chair: Dr. Zheng ZHU (Monet Room A)

10:50 – 12:20	**MULTI-PLATFORM GAME AND OPERATION OF EBIKE-BIKE SHARING SYSTEMS BASED ON REINFORCEMENT LEARNING** Ziyi SHI and Zheng ZHU
	RISK-AVERSE DYNAMIC SYSTEM OPTIMAL TRAFFIC ASSIGNMENT FOR RIDE-SHARING SYSTEMS Riki KAWASE
	OPTIMAL COMPENSATION SCHEME DESIGN FOR INTEGRATIVE SHARED MOBILITY SERVICES Jiangyan HUANG and Min XU

Session D3: Logistics and Supply Chain II
Session Chair: Dr. Ran YAN (Monet Room B)

10:50 – 12:20	**AN EXTENDED SMART 'PREDICT, AND OPTIMIZE' (SPO) FRAMEWORK BASED ON SIMILAR SETS FOR SHIP INSPECTION PLANNING** Ran YAN, Shuaian WANG, and Lu ZHEN
	USING TWITTER DATA TO ESTIMATE TRUCK DELAY COSTS DUE TO MOTOR VEHICLE COLLISIONS ON RURAL HIGHWAYS IN ALBERTA, CANADA S. ABOLHOSEINI, P.K. PATNALA, J.D. REGEHR, and B. MEHRAN
	EMERGENCY RESPONSE RESOURCE ALLOCATION CONSIDERING VEHICLE TYPES Changle SONG, David LEVINSON, and Emily MOYLAN

The presenter(s) of each paper is underlined.

Detailed Presentation Schedule

Day 2: 14 December 2023 (Thursday)

International Scientific Committee Meeting Chair: Prof. Michael G.H. BELL (Picasso Room A)	
10:50 – 12:20	All International Scientific Committee members

Session D4: Bus Operations Session Chair: Dr. Enoch LEE (Picasso Room B)	
10:50 – 12:20	**THE ROLE OF RIGHT TURNS IN BUS OPERATION** T. XIAN, J.D. NELSON, and E. MOYLAN
	INTEGRATION OF FLEXIBLE BUS AND PARCEL DELIVERY UNDER STOCHASTIC DEMAND AND SERVICE TIME Enoch LEE, Manzi LI, and Hong K. LO
	BUS ROUTING-SCHEDULING DESIGN UNDER STOCHASTIC DEMAND Yingying LIN, Wei HUANG, and Jiemin XIE

The presenter(s) of each paper is underlined.

Detailed Presentation Schedule

Day 2: 14 December 2023 (Thursday)

Session E1: Evacuation and Disaster Relief II
Session Chair: Prof. Jan-Dirk SCHMÖCKER (Picasso Room)

13:20 – 14:50	**SIMULATING PEDESTRIAN EVACUATION IN HALL USING ARTIFICIAL INTELLIGENT ALGORITHM** B.L. CEN, Y. XUE, and K. ZHANG
	ENDOGENOUS STOCHASTIC EVACUATION OPTIMISATION FOR DRONE-ASSISTED EVACUATION Jose ESCRIBANO, Ali Gul QURESHI, Jan-Dirk SCHMÖCKER, and Panagiotis ANGELOUDIS
	EQUITABLE SEQUENCE TO RESTORE TRANSPORTATION NETWORK LINKS AFTER EXTREME DISASTER K.C. WIJAYA and K. SAKAI

Session E2: Rail System Vulnerability
Session Chair: Dr. Yili TANG (Monet Room A)

13:20 – 14:50	**EVALUATING THE FLOODING LEVEL IMPACTS ON URBAN METRO NETWORKS AND TRAVEL DEMAND: BEHAVIORAL ANALYSES, AGENT-BASED SIMULATION, AND LARGE-SCALE CASE STUDY** B. ZHAO, Y. TANG, C. WANG, S. ZHANG, and K. SOGA
	THE VULNERABILITY EVALUATION OF METRO STATIONS – A CASE STUDY IN WUHAN, CHINA Shuyang ZHANG, Chenglu WANG, Manzi LI, Guojun CHEN, and Haode LIU
	UNDERSTANDING EVOLUTION OF URBAN RAIL TRANSIT SYSTEM VULNERABILITY UNDER NETWORK EXPANSION: A CASE STUDY OF HONG KONG MTR NETWORK Yingying XU, Yu GU, and Anthony CHEN

Session E3: Transportation Network Resilience II
Session Chair: Prof. Biyu CHEN (Monet Room B)

13:20 – 14:50	**HOW THE RISE OF TRUCKS HAS REDUCED NETWORK TRAFFIC THROUGHPUT** Yang GAO and David LEVINSON
	OPTIMIZATION OF RESELLING CANCELED ORDERS STRATEGY USING DEEP Q-NETWORKS WITH A CASE STUDY OF THE STEEL SLITTING INDUSTRY Yang DENG, Andy H.F. CHOW, Zhili ZHOU, and Chengshuo YING
	RELIABLE LIFELONG PLANNING A*: TECHNIQUE FOR REOPTIMIZING RELIABLE SHORTEST PATHS IN DYNAMIC NETWORKS Wenxin TENG and Biyu CHEN

The presenter(s) of each paper is underlined.

Detailed Presentation Schedule

Day 2: 14 December 2023 (Thursday)

Session E4: Pricing and Reward
Session Chair: Dr. Xiaoran QIN (Picasso Room A)

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	SPATIAL-TEMPORAL PRICING FOR COMPETITIVE RIDE-SOURCING PLATFORMS BASED ON MULTI-AGENT REINFORCEMENT LEARNING METHOD Chuqiao CHEN, Haonan YANG, Chujiu ZHAI, Xiqun CHEN, and Dong MO

Session E5: Transport Planning and System Design
Session Chair: Dr. Haruko NAKAO (Picasso Room B)

13:20 – 14:50	**OPTIMAL MIXED FLEET AND CHARGING INFRASTRUCTURE PLANNING TO ELECTRIFY DEMAND RESPONSIVE FEEDER SERVICES UNDER STOCHASTIC DEMAND** Haruko NAKAO, Tai-Yu MA, Richard CONNORS, Francesco VITI, and Yumeng FANG
	ENHANCING TRANSPORTATION NETWORK RESILIENCE BY REDUNDANT DESIGN: A COMPACT MATHEMATICAL PROGRAMMING APPROACH Zijian WANG, Xiangdong XU, Xiangyi FAN, and Yonglei XU
	A STUDY ON THE DESIGN OF A RESERVATION SYSTEM FOR URBAN TRANSPORT SERVICES UNDER UNCERTAINTY Koki SATSUKAWA, Yusuke HARA, Yosuke KAWASAKI, and Takamasa IRYO

The presenter(s) of each paper is underlined.

Detailed Presentation Schedule

Day 2: 14 December 2023 (Thursday)

Session F1: Rail Transportation
Session Chair: Dr. Ka Ho TSOI (Picasso Room)

15:10 – 16:40	**RAILWAY RESILIENCE: PASSENGER-HOUR DELAYS UPON SERVICE DISRUPTIONS** Ka Ho TSOI and Becky P.Y. LOO
	A BI-LEVEL DEEP REINFORCEMENT LEARNING FRAMEWORK FOR METRO TRAIN SCHEDULING AND SPEED CONTROL UNDER STOCHASTIC DISTURBANCES Shouyi WANG, Yanzuo LIN, and Andy H.F. CHOW
	AN EMERGENCY DISPATCH MODEL FOR DOCKLESS SHARED BICYCLES IN RESPONSE TO METRO DISRUPTIONS Rui XU, Xinyuan WANG, Junlong ZHANG, and Jian LI

Session F2: Network Resilience and Recovery
Session Chair: Prof. Yu ZHOU (Monet Room A)

15:10 – 16:40	**ASSESSING RESILIENCE OF MULTI-MODAL TRANSIT NETWORKS: AN ACTIVITY-BASED ACCESSIBILITY ANALYSIS** Yuqing ZHOU and Xiao FU
	ALGORITHMS FOR OPTIMAL REPAIR SEQUENCING OF DAMAGED ROADS AFTER DISASTERS Jaswant SINGH and Hemant GEHLOT
	DYNAMIC MOBILITY MANAGEMENT FOR HETEROGENEOUS POST-DISASTER POPULATION WITH HIDDEN MARKOV MODEL – A CASE STUDY IN SRI LANKA D.H.M.K.S. THALGASKOTUWA and E. HATO

Session F3: Traffic Prediction
Session Chair: Prof. Simon HU (Monet Room B)

15:10 – 16:40	**NETWORK-LEVEL TRAFFIC STATE ESTIMATION METHOD FOR MULTIPLE TIME PERIODS CONSIDERING THE MISSING TRAFFIC DATA** R. TANI, K. UCHIDA, and Anthony CHEN
	A POISSON-BASED DISTRIBUTION LEARNING FRAMEWORK FOR SHORT-TERM PREDICTION OF FOOD DELIVERY DEMAND RANGES Jian LIANG and Jintao KE
	MASTGAT: A MULTI-ATTRIBUTE SPATIAL-TEMPORAL GRAPH ATTENTION NETWORK FOR TRAFFIC PREDICTION Xinlong HUANG, Renxin ZHONG, Panagiotis ANGELOUDIS, Michael G.H. BELL, Der-Horng LEE, and Simon HU

The presenter(s) of each paper is underlined.

Detailed Presentation Schedule

Day 2: 14 December 2023 (Thursday)

Session F4: Connected Vehicles and Traffic Assignment
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	BOUNDEDLY RATIONAL CONTINUUM USER EQUILIBRIUM MODEL FOR SIMULTANEOUS DEPARTURE TIME AND ROUTE CHOICE IN TRAFFIC ASSIGNMENT PROBLEMS Liangze YANG, Jie DU, S.C. WONG, and Chi-Wang SHU

Session F5: Transportation Network Reliability II
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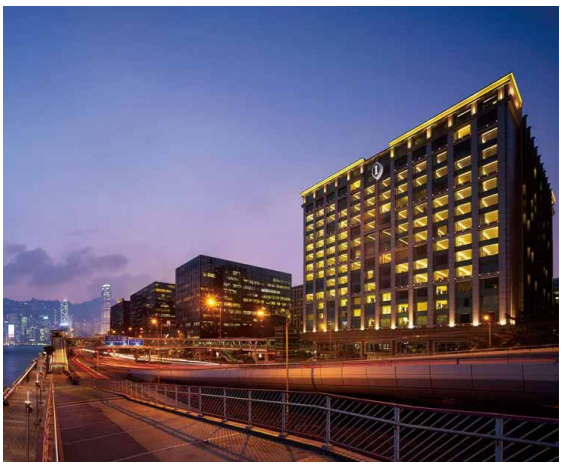
	OPTIMAL PUBLIC TRANSPORT FARE WITH DELAY INSURANCE TO IMPROVE TRAVEL TIME RELIABILITY Yihe ZHOU, Wenzhe SUN, and Jan-Dirk SCHMÖCKER
	ESTIMATION OF INDIVIDUAL-LEVEL PARAMETERS FOR A JOINT ROUTE AND DEPARTURE-TIME CHOICE MODEL CONSIDERING TRAVEL TIME RELIABILITY Dai TAMAGAWA, Mariko NAKAI, Shinji NAKAGAWA, Daisuke FUKUDA, Makoto CHIKARAISHI, and Yasuo ASAKURA

The presenter(s) of each paper is underlined.

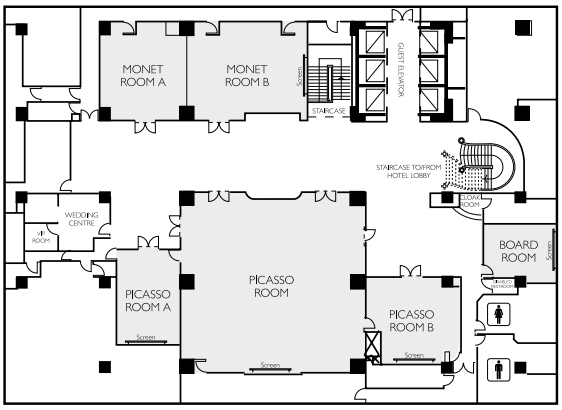
Symposium and Banquet Venues



Symposium Hotel:

InterContinental Grand Stanford Hong Kong

70 Mody Road, Tsim Sha Tsui, Kowloon, Hong Kong



Symposium Venue

Symposium Venue:

The conference rooms at B1 Level

InterContinental Grand Stanford Hong Kong

Symposium Lunch Venue:

Opera Room (B3 Level)

InterContinental Grand Stanford Hong Kong

Symposium Banquet Venue:

Tsim Tung Ho Choi Seafood Restaurant

UG/F, Empire Centre, 68 Mody Road, Tsim Sha Tsui, Kowloon, Hong Kong

Abstract Compendium

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KEYNOTE SESSION

ENHANCING TRANSPORTATION SYSTEM RESILIENCE THROUGH TECHNOLOGY: LESSONS FROM THE PANDEMIC

Hani MAHMASSANI
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While the pandemic brought along disruptions to everyday economic and social activities at an unprecedented scale, it also demonstrated the degree to which our systems are respectively both vulnerable and resilient. On the demand side, the large scale adoption of telemobility, or the reliance on information and communication technologies for work, commerce, health and entertainment, provided a lifeline for individuals, firms and institutions. On the supply side, alternative modes of travel for both personal and freight mobility played increasingly important roles as dominant modes were disrupted. For example, intermodal freight rail in the US stepped up to keep essential supply chains moving when trucking was severely disrupted by health concerns. However, severe post-pandemic shocks to the supply chain showed the brittleness of hyper-optimized delivery systems. In urban mobility, transportation network companies have provided flexibility needed for changing hybrid work travel patterns that may not be as well served by conventional transit modes. This presentation will present various examples of resilience and disruptability that can help guide the design and operation of more resilient future transportation networks and logistics systems, and leverage the role of technology in these processes.

DRIVER SCHEDULING MODELS UNDER STOCHASTIC TRAVEL TIMES

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Driver scheduling is optimized based on given bus timetable and bus travel time under the restrictions of labor working hours. The stochastics and dynamics of travel time make the scheduling problem even harder. This study proposes two driver scheduling models considering travel time variability: the flexible and fixed shift models. The flexible shift model is to assign bus trips to drivers based on time-space networks so as to minimize total cost; while the fixed shift model is to firstly enumerate legal and cost-efficient shifts and then to determine optimal numbers of drivers for each of shifts by using Genetic Algorithms (GAs) with optimal bus trip assignment. A case study on Taipei-Yilan freeway bus route is conducted. The model results show that the fixed shift model performs, although 7.98% higher operation cost, much efficient (saving 90% computation time) than the flexible shift model. It is also shown that to accommodate the travel time variability, the driver cost can be reduced by approximate 15%, suggesting the importance in considering the travel time variability.

Abstract

VULNERABILITY ASSESSMENT OF TRANSPORTATION AND POWER NETWORKS CONSIDERING INTERDEPENDENT STRUCTURES

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In the evaluation of resilience against disasters, the importance of considering the interdependency of infrastructure structures in management has been demonstrated. This study focuses on the transportation and power networks, attempting to describe their relationships. Particularly, by taking into account the characteristics of the power network, the study evaluates the connectivity of the power network as an optimal power flow problem. Additionally, it represents the mutual impacts of the two networks as a graph model. Furthermore, by constructing a connectivity vulnerability assessment model and conducting scenario analysis assuming disaster occurrence, the study assesses connectivity and vulnerability considering interdependence.

A RELIABILITY-BASED PATH-FINDING ALGORITHM WITH CONSIDERATION OF TRAVEL TIME AND ENERGY CONSUMPTION UNCERTAINTIES

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This study proposes a bi-objective reliable path-finding algorithm for routing vehicles on a road network, with vehicles' energy consumption uncertainty and travel time uncertainty. A bi-objective stochastic optimization problem is proposed and formulated to simultaneously maximize energy consumption reliability (ECR) and travel time reliability (TTR). ECR is defined as the probability of finishing a trip without exhausting a given energy consumption budget, while TTR is the on-time arrival probability with the travel time budget. In this study, the proposed optimization problem is decomposed into two sub-problems: (1) finding the most reliable paths for maximizing the TTR objective and (2) finding the most reliable path for optimizing the ECR objective. Then, a novel ranking algorithm is proposed to exactly solve the formulated optimization problem. A case study is carried out on Hong Kong's road network to demonstrate the efficacy and efficiency of the proposed algorithm for real-world applications.

SESSION A1: TRANSPORTATION NETWORK RELIABILITY I

RELIABILITY IMPROVEMENT WITH PARKING RESERVATION SERVICE CONSIDERING PARKING UNCERTAINTY

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Parking reservation, with the booming of smart parking technologies, has been applied in cities and is becoming more and more popular. It can reduce parking cruising time, alleviate illegal parking, and improve parking service. To avoid the conflict caused by random late departures and/or early arrivals of parking users, this paper proposes a two-stage model to improve the reliability of the parking reservation service. During the reservation stage, the parking system solves the parking matching problem aiming at maximizing matches and publishes the results without specific space information. Based on the initial allocation result and real-time parking information, state updating and dynamic allocation during the service stage are executed to resolve conflicts between requests. Numerical experiments demonstrate that the proposed model significantly improves matching success rate and parking utilization rate compared with that at the basic model. The improvement effect remains unaffected by supply-demand relationships and is correlated with the degree of parking uncertainty.

Keywords: Parking reservation, parking reliability, parking uncertainty, dynamic allocation, parking utilization rate.

THE OPTIMAL LINK ESTABLISHMENT PROBLEM FOR ENHANCING NETWORK CONNECTIVITY RELIABILITY UNDER MULTIPLE SCENARIO DISASTERS

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A connectivity of transportation network in the disaster is very important. Road networks are also essential for the transport of relief supplies. This study proposes the network design problem that establishes the links in road networks to ensure a connectivity during disasters. The multiple disaster scenarios with link disruptions are assumed and an optimal link establishment design problem is formulated as mixed integer problem considering the travel cost from the disaster prevention bases and the cost of link constructions. Furthermore, the Benders Decomposition algorithm was shown to be effective in reducing the computational load for the proposed model for a large number of scenarios. Validated by giving random disrupted links as the disaster scenarios using Sioux falls network, the results showed that the greater the number of disrupted links, the more links are established.

Keywords: Connectivity, disaster prevention, optimization, network design problem, benders decomposition.

Abstract

IMPACT OF URBAN MORPHOLOGY ON THE RELIABILITY OF ELECTRIC ON-DEMAND FEEDER SERVICES

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Urban morphology, the physical form and layout of the city including streets, transport infrastructure and land use patterns, highly influences the spatial distribution of travel demand. As urban morphology evolves (e.g., urban sprawl), so the travel demand patterns that tend to arise will change. This may impact upon the performance of Mobility on-Demand services such as demand responsive feeder services (DRFS). Electric DRFS (E-DRFS) may be particularly susceptible to perturbations in the distribution of demand; due to battery capacity constraints, the configuration of charging infrastructure determines service performance, and it cannot easily be modified to respond to demand changes. Day-to-day spatiotemporal variability in demand impacts vehicle routing and hence energy consumption, making fleet planning and charging management a challenging problem. To design and provide a reliable E-DFRS, this study aims to understand how urban morphology influences the reliability of E-DRFS given stochastic demand characteristics. Previous research has focused on the performance of mobility-on-demand services in terms of service area characteristics and perturbation in demand patterns. However, some only focus on the temporal perturbation while others investigate highly simplifies case with one vehicle. Besides, none have focused specifically on the context of E-DRFS. To address these issues, this research aims to understand which dimensions of urban morphology bring systematic changes in the performance of E-DRFS, assuming synthetic but somewhat realistic scenarios. The main focus is the impact of urban morphology on service reliability under stochastic demand. The ensembles of simulation experiments are conducted to investigate the impact of changes in the distribution pattern and density of demand on the reliability of E-DRFS. Preliminary results suggest that systematic changes in some key performance indicators (KPIs) can be identified, and the study is currently conducting additional simulation experiments to gain a better understanding of these complex interactions and identify systematic trends.

Keywords: Electric vehicle, demand responsive feeder services, urban morphology, demand stochasticity, service reliability.

SESSION A2: EVACUATION AND DISASTER RELIEF I

HOW DOES THE PROPORTION OF CHILDREN IN NEED AFFECT EVACUATION EFFICIENCY?

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The percentage of children attending kindergartens keeps increasing, and the countries face challenges in improving the safety of preschool children. In this study, the kindergarten evacuation is simulated, considering the impact of the ratio of children in need of help on evacuation efficiency. The evacuation time and flow are investigated to measure the influence of the ratio. With the increasing ratio of children in need of help, evacuation time increases linearly, and flow decreases exponentially. Duncan's multiple range test is adopted, and the results show that when more than 40% of children require help, the influence of increasing ratio of children in need on reducing flow is not always significant. This study can give suggestions for the kindergarten evacuation plan and crowd management for children.

Keywords: Evacuation simulation, kindergarten evacuation, crowd management, assisted children evacuation.

EVACUATION ANALYSIS OF SUDDEN LARGE PASSENGER FLOW IN URBAN RAIL TRANSIT HUB: A CASE OF BEJING SOUTH RAILWAY STATION

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Transport hub is responsible for the travel and interchange of urban passenger flow, which plays an important role in urban transport system. Urban transport hub characterizes the high passenger flow density. Sudden large passenger flows are easily to occur during holidays or disruptions. To improve sudden large passenger evacuation efficiency of transport hub, it is necessary to study passenger transfer efficiency. This research focus on the problem that what is the influence of the passenger number distribution of different transfer modes on the evacuation efficiency of the hub. In this study, the pedestrian transfer network of Beijing South Railway Station (BSRS) is firstly presented in order to study the transfer behavior of passengers. Combined with existing studies, the pedestrian transfer time estimation with sudden large passenger flow is proposed, and the evacuation efficiency is measured. Moreover, the influence of passenger transfer patterns on evacuation efficiency of urban rail transit is studied by considering the passenger number distribution of different transfer modes. It provides a theoretical basis for designing evacuation scheme of sudden large passenger flow in urban rail transit hubs.

Keywords: Sudden large passenger flow, evacuation, urban rail transit hub, Beijing south railway station.

Abstract

URBAN MULTI-MODAL TRANSPORTATION NETWORK RECOVERY STRATEGIES FROM A RESILIENCE PERSPECTIVE

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Resilience, as an important indicator to measure the transportation system's resistance to external attacks and quickly rebound to an acceptable service level, reflects the dynamic process of the system from a normal initial state, experiencing performance loss and reaching to a new steady state. Considering that various travel modes in the urban transportation system can be substituted for each other, this study applies the cascade failure model to simulate the scenario when the multi-modal transportation network is attacked. Then the genetic algorithm is used to analyze the structural resilience of the damaged multi-modal transportation network. A case study was made for the multi-modal transportation network in Changsha City and several restoration strategies were made. The proposed network resilience restoration method is expected to be implemented in practice to improve the ability of a city to resist attacks.

Keywords: Urban multi-modal transportation, structural resilience, capacity-load model, recovery strategy, genetic algorithm.

SESSION A3: COVID-19 AND EPIDEMICS

HOW AIR TRANSPORT NETWORKS RESPOND TO LONG-LASTING DISRUPTIVE EVENTS LIKE COVID-19: THE FIRST STEP TOWARD LONG-TERM RESILIENCE

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Resilience is critical for the air transport network (ATN) to cope with disruptive events like the COVID-19 pandemic, while the first step in understanding resilience is to reveal how the ATN responds to disruptions. This paper presents a method for investigating how the ATN responds to the COVID-19 pandemic from its outbreak through deterioration, adaptation, and restoration. The concept of system state is introduced to investigate when the ATN has substantially changed. By comparing the structure of the temporal ATN in different weeks based on network similarity assessment, the changing points of the ATN are detected, where the network system has switched from one state to another. To quantify what are the changes to the ATN's structure, several performance metrics, including global and local connectivity, are evaluated around the changing points. Moreover, to study the response time of the ATN to the pandemic, the time lag between the changing points of the ATN and that of the confirmed cases is examined. Finally, the proposed method is applied to the ATNs of Mainland China and the U.S. during the COVID-19 pandemic, resulting in some interesting findings and policy implications. It is found that in a pandemic outbreak, China is more likely to suspend routes directly, while the U.S. is reducing flight frequency to maintain essential airport connections. Further, the state transition of ATNs caused by policies is temporary, while the state change caused by the pandemic is permanent.

Keywords: Air transport network, resilience, system state, structure variation, time lag.

VARIANT PATTERNS AND INFLUENCE OF INTER-REGIONAL TRAVEL DURING THE SARS-COV-2 EXPANSION IN SOUTH AFRICA

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We evaluated the dynamic impacts of three types of human mobilities, including provincial inflows, cross-district flows, and within-district flows, on daily reported COVID-19 cases for 2020. The model is built through a structural equation modeling method. We performed regressions on dynamic panel datasets. We found that the three types of human mobilities affected the daily new COVID-19 case numbers in alternative or overlapping ways during the emergent stage of the epidemic. Within-district flows played a key role in increasing the cases during the spreading stage. In the epidemic stage, we observed a high but slowly decayed impact of within-district mobility on daily new cases which is potential evidence of the efficacy of non-pharmaceutical interventions (NPIs).

Keywords: SARS-CoV-2, human mobility, COVID-19, lockdown policy, dynamic effects.

Abstract

EVALUATING TRAVEL BEHAVIOR RESILIENCE ACROSS METROPOLITAN AND RURAL AREAS DURING THE COVID-19 PANDEMIC: CONTRIBUTIONS OF VACCINATION AND EPIDEMIOLOGICAL INDICATORS

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The COVID-19 pandemic has severely disrupted travel behavior across diverse socio-economic areas, with a significant impact on transportation systems, public health, and the economy. As countries both recover and plan for future virus-driven stresses, it is crucial to identify the drivers of building travel behavior resilience, such as vaccination. Using an integrated dataset with over 150 million US county-level mobile device data from 01/01/2020 ~ 20/04/2021, we establish a Bayesian structural time series (BSTS) model to infer the relative impact of the vaccination intervention on five types of travel behavior across Metropolitan, Micropolitan, and Rural areas. Further, we develop a Partial Least Squares Regression (PLSR) model to accurately estimate how vaccination rates, COVID epidemiological indicators (e.g., COVID incidence rates, death rates, and testing rates), and weather conditions (e.g., temperature, rain, and snow) would impact each type of travel behavior across diverse areas during the recovery period of the pandemic. The results shed light on how effective vaccinations are in boosting resilience in travel behaviors and how human mobility response varies in response to vaccination rates, epidemiological indicators, and weather conditions in Metropolitan, Micropolitan, and Rural areas. Our findings can inform decision-making, equitable planning, and the development of sustainable and resilient transport systems that can adapt to a future pandemic.

Keywords: COVID-19, vaccination, travel behavior resilience, Bayesian structural time series, partial least squares regression.

SESSION A4: LOGISTICS AND SUPPLY CHAIN I

APPLYING PAGERANK FOR DETECTING CRITICAL NODES IN ROAD FREIGHT TRANSPORTATION NETWORK

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PageRank is a well-known mathematical model to rank websites based on users' behavior. This study explores the prospects of using PageRank formulation to find the critical nodes in a road freight transportation network, which highlights the network's vulnerability and provides valuable information for more resilient route planning. More specifically, we use Personalized PageRank and investigate its performance against different transportation scenarios to find critical nodes in the network. Finding critical nodes in a network is a famous problem and is known in the literature as the Critical Node Problem (CNP). In CNP, the goal is to optimize a connectivity metric at the network level by deleting 'k' nodes or minimize the number of nodes to delete by bounding the connectivity metric to an acceptable threshold. The outcome is the set of critical nodes which gives the optimum network performance measured in terms of the connectivity metric used. In this study, we take a different paradigm to approach this problem and use the PageRank algorithm to find the critical nodes. The basic difference between the CNP and our approach is that the CNP is an optimization problem where an assessment is made about the network after the deletion of the nodes at every instance. Hence, node deletion is part of the optimization problem and posterior network analysis is the basis to decide on the criticality of the nodes. Whereas Personalized PageRank finds the long-term relationship between the network nodes using random walk with restart and influences the nodes' criticality by incorporating the criticality of the neighboring nodes, without any node deleting mechanism during the process.

Keywords: PageRank, critical nodes, road network, network vulnerability, critical node problem, resilient routes.

STOCHASTIC SERVICE NETWORK DESIGN FOR BUS-INTEGRATED FREIGHT TRANSPORT SYSTEMS

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This paper studies a bus-integrated freight transport system in which the spare capacity of buses is utilized to transport freight. We focus on the service network design of the freight system after the introduction of buses. Uncertainty in freight volume and passenger flows is explicitly recognized and the problem is formulated as a two-stage stochastic programming model. In the first stage, truck fleet sizing and truck scheduling are made based on the distributions of freight demand and passenger flows. In the second stage when the actual freight demand and passenger flows are revealed, freight allocation and ad-hoc service are determined accordingly. Given the complexity of the problem, the L-shape approach would be used for solving the two-stage stochastic programming problem.

Keywords: Bus-integrated freight transport system, service network design, uncertainty, stochastic programming.

Abstract

ANALYSIS OF CONTAINER SHIPPING SCHEDULE STABILITY

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A consequence of the pandemic has been significant disruption to global container flows, with cargo spending longer in containers, container carrier congestion in ports, and container dwell times in terminals increasing. After reviewing 2020 and 2021 data for the trans-Pacific trade lane, this paper presents a mathematical model that explains how these factors are relate to each other. The model highlights the importance of the speed with which containers are loaded and unloaded for the dwell time of container carriers in ports, the dwell time of containers in terminals, and rollovers (containers left behind). It is shown that port congestion propagates to all ports in the same port rotation (tour). An analysis of the mathematical model indicates precisely when the "tipping point" is reached and congestion propagates. The mathematical model also suggests some remedies, like reducing the number of ports in port rotations and increasing productivity at one port to compensate for a loss of productivity at another on the same port rotation.

Keywords: Container shipping, port congestion, schedule stability, pandemic disruptions.

SESSION A5: TRAVEL BEHAVIOR I

MEASURING CRASH-INDUCED TRAVEL DELAYS: AN APPROACH USING GPS DATA

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Road crash-induced travel delays contribute significantly to post-crash costs, yet their accurate measurement remains challenging. Traditional approaches often depend on speed detectors or police-reported durations. This study develops a method for quantifying travel delays resulting from road crashes, using GPS data and other open-source spatial data. Our approach, applied specifically to Hong Kong using taxi GPS data, allows for a more comprehensive and precise evaluation. Additionally, we employ a generalized linear model to explore the associations between travel delays and various factors, including crash characteristics, temporal attributes, road network and traffic indicators, and built environment features. Our findings reveal significant correlations between travel delays and factors such as lighting conditions, proximity to the nearest ambulance depot, degree centrality of road segments, and the presence of certain types of Points of Interest (POIs). We estimate the total crash-induce travel delays from January to November 2021. By considering passenger time losses, the associated economic cost is estimated. The proposed workflow offers a robust tool for post-crash evaluations in terms of travel delay costs. Our findings underscore the importance of accurately evaluating travel delays in a complex urban road network setting, thereby contributing to more effective road safety management and policy-making.

Keywords: Travel delays, road crashes, road safety, GPS data.

HOW DO PEOPLE VALUE RELIABLE MODES IN THEIR TRANSIT PATH CHOICES?

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Using transit survey data with used-path observation and GTFS, this study conducted a comparative analysis between reliable-mode-including and bus-only transit paths (RP and BP), where the former refers to transit paths with bus rapid transit or light rail transit trip leg(s). For each survey respondent, we identified multiple transit paths with an existing transit assignment algorithm. We then paired one RP and one BP to compare the attributes of the two paths using logistic regression models. The models were designed to control for path attributes such as total travel time and walking time and were able to quantify the advantages of RP compared to BP. The resulting models could map these attributes to the RP choice probability with respect to different values of path attributes. The models were also able to provide practical numbers such as the proportion of transit users who would choose RP over BP when the two paths' travel times are the same, as well as the extent to which passengers consider RP and BP to be equivalent. Our results confirmed the preference for RP over BP, particularly on their reliability. Finally, we demonstrated how the preference varied based on travel contexts and demographics.

Keywords: Choice set generation, transit path choice, BRT, LRT, logistic regression.

Abstract

ASSESSING THE RELIABILITY OF ROUTE CHOICE SETS: CONSIDERING THE SIMILARITY BETWEEN ALTERNATIVES

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This study seeks to find a strategy to evaluate the reliability of generated choice set in route choice modelling. Previous studies focus more on optimizing the capture rate and minimizing the choice sets, but only some studies consider the realism of alternative routes. Labelling and link penalty approaches are combined to create the choice set. Overlap, deviation and internal similarity, which measures how different one route is from the others, are included to assess the performance of the choice set. GPS information of 4538 real trips from 131 travelers in 2008 was collected and analyzed in Minneapolis – St. Paul (The Twin Cities) as part of the I-35W Bridge Collapse study used in this study. The high-resolution road network of the Twin Cities includes 108,561 nodes and 277,747 links. Overall, with the best 10 labels, on average 40 unique routes are generated for each OD pair, and around 80% of all observed trips could be captured with an 80% overlap threshold. About 88% of all observed trips have an average deviation within 50m compared to the best matching result when combining all labels introduced in this study. For most OD pairs, the internal similarity Z is between 0.15 and 0.2.

Keywords: Route choice, choice set generation, choice set evaluation, internal similarity, reliability.

SESSION B1: TRAVEL BEHAVIOR II

MODELLING ROUTE CHOICE BEHAVIOR CONSIDERING DRIVERS' INFORMATION ACQUISITION PROCESS

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This study develops a rationally inattentive recursive logit (RIRL) model, which integrates the recursive logit and rational inattention models for incorporating the en-route information acquisition process of drivers in networks. The model is further extended to the case where the network traffic is congested by formulating the RIRL user equilibrium (RIRL-UE) assignment. We simulate the effect of the information provision on the route choice behavior of the single driver and the route traffic flow in the Nguyen-Dupuis network. The simulation results indicate that a single driver's expected travel time increases as the unit information cost increases. On the other hand, the total travel time of the group of drivers is unrelated to the unit information cost. Regarding the spatial distribution, the expected travel time of a single driver can improve if the information is provided so that the driver can choose the risky link correctly. The total travel time of the group of drivers improves if the unit information cost is low in some links; however, we cannot find the typical characteristics of the effective link to provide the information. The adverse effects of the information are also found in the simulation of the single driver and group of drivers.

Keywords: Link-based route choice model, rational inattention model, stochastic network, information acquisition, user equilibrium.

MODELLING ROUTE CHOICE BEHAVIOR UNDER RISKY TRAVEL TIME: A REGRET-BASED APPROACH WITH MULTIPLICATIVE ERRORS

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This study aims to better understand travelers' route choice behavior under risky travel time using advanced travel choice models. To reflect the risky travel time, this study uses the concept of the mean-variance model composed of travel time and travel time variability. This model allows us to measure risk aversion or risk proneness. The regret-based Frechit model is applied to analyze the route choice behavior and compared their performance with other utility-based models. Two types of data on route choice behavior are applied. The first synthetic data simulates travelers' route choice behavior under risk perception. We show how the models differently predict route choice behavior by different types of risk perception. The second data is from a face-to-face stated preference survey of route choice for intercity travel, collected in South Korea. Travelers' risk perceptions and preferences would be heterogeneous. Therefore, to capture the heterogeneity, we further apply the latent-class regret-based Frechit model. Our results show how travelers with different risk perceptions empirically show different preferences.

Keywords: Route choice behavior, travel time variability, regret-based choice models, risky travel time, multiplicative errors.

Abstract

EMPIRICAL ANALYSIS OF ROUTE CHOICE BEHAVIOR UNDER TRAFFIC RESTRICTIONS DUE TO RECONSTRUCTION WORKS OF URBAN EXPRESSWAY

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Recently, the aged expressways in Japan require large scale reconstruction works with lane closure or complete closure of road sections. Detailed understandings of the impact of traffic regulations, based on actual cases, will lead to an improvement of traffic management during renewal works in the future. This study focuses on the user's detour behavior during reconstruction works of the Hanshin Expressway in Osaka, Japan in November 2019. In order to know the impact of road reconstruction work to travel behaviour, this study proposed an index for evaluating variety of route choice in the normal and restricted road networks and analyzed actual route choice changes in those different networks by using commercial vehicle trajectory data. It was found that the routes in gate pairs which used target road sections frequently during normal became particularly various when the section was closed. Additionally, the results indicated that the road types included in the route might be more related to trip length than the spatial extent of the chosen detour route.

Keywords: Route choice, traffic restriction, trajectory data, expressway, entropy index.

SESSION B2: NETWORK VULNERABILITY AND RELIABILITY

DISCONNECTION DURATION TIME BETWEEN TWO NODES CONSIDERING CORRELATION AMONG LINK CLOSURES IN ROAD NETWORKS

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This study proposes a stochastic model which calculates the connectivity reliability between origin-destination (OD) pairs as the disconnection duration time due to multiple link closures in a road network. The link closure can occur by natural disasters. This model assumes that the number of link closures occurring among several links in a network follows a multivariate Poisson distribution and that link closure duration for each link follows a lognormal distribution. The disconnection duration time between OD pairs is calculated as a random variable by considering statistical correlation among the number of link closures. This model evaluates the connectivity reliability in view of the disconnection duration time between OD pairs in road networks.

Keywords: Connectivity reliability, multivariate Poisson distribution, lognormal distribution.

CRITICAL LINK SELECTION CRITERIA IN CONGESTIBLE TRANSPORT NETWORKS

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The resilience of a congestible road network is frequently measured by the network robustness index (NRI), i.e. the maximum increase in total network travel time which is associated with the disruption of one directed link. Since this is hard to compute for large networks, the paper proposes alternative criteria for the identification of the critical link. The following measures are used: the link characterized centrality, the link total distance, and the link eigen-score. A numerical comparison of the criteria is provided for the Sioux Falls network. The demand matrix is changed and the distributions of the total network travel time increase that are obtained according to the different critical link selection criteria are compared with the NRI distribution.

Keywords: Centrality measure, congestion, critical link, network robustness index, road network.

Abstract

ANALYZING TRANSPORTATION NETWORK VULNERABILITY TO CRITICAL-LINK ATTACKS THROUGH TOPOLOGY CHANGES AND TRAFFIC VOLUME ASSESSMENT

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The transportation system is often considered the most critical infrastructure since it impacts people's health, safety, comfort, and economic activities. Therefore, disruptions to transportation system components, whether caused by natural disasters or human actions, can have significant impacts on the economy and social well-being. To maintain the serviceability of transportation networks during disruptive conditions, it is essential to identify critical segments that are vulnerable to disruptions and understand their impact on network performance. This study proposes a method for identifying the critical components of a transportation network and assessing the network's vulnerability by utilizing topological parameters as a proxy for performance. Additionally, a modeling framework is developed using these parameters to evaluate the impact of critical-link attacks on traffic flow changes. The Colombo Municipal Council Area in Sri Lanka was chosen as the case study area due to its regional importance and susceptibility to environmental disasters. The study's findings would be beneficial in understanding the impact of critical-link attacks on transportation network performance and traffic flow, as well as in preparing precautionary measures to maintain optimal transportation network serviceability.

Keywords: Transportation network vulnerability, critical-link attacks, network performance, traffic volume, topology.

SESSION B3: PUBLIC TRANSPORTATION I

ROBUST INTEGRATED PLANNING ON EN-ROUTE CHARGER DEPLOYMENT AND CHARGING SCHEDULING FOR URBAN ELECTRIC BUS SYSTEMS

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Public transit (PT) operators are now replacing their existing bus fleets with electric buses (EBs), which are expected to be a viable mobility alternative to reach the goal of carbon neutrality. Fast en-route charging technology has been adopted to recharge EBs during the dwell time to tackle the driving range issue. This study aims to simultaneously optimize en-route charger deployment, charging schedule and the bus battery size by minimizing the total cost of PT operators. We first formulate this problem as a deterministic model by considering a series of practical factors such as the weight-related energy consumption, charging capacity, the minimum charging time requirement, time-of-use (TOU) rates and demand charges. Then we further consider the energy consumption uncertainty to formulate the problem as robust models by incorporating three different types of uncertainty sets. Furthermore, these models are reformulated as tractable counterparts, which can be solved efficiently by off-the-shelf solvers. Numerical experiments are carried out to demonstrate the applicability of our approaches and results show that our proposed models can effectively solve the proposed integrated optimization problem of an EB system, and the optimal solution optimizes the number of chargers, charging schedule and battery size at the same time. The results may help the PT operators to make a decision that balances the investments and the level of the robustness of the EB system.

Keywords: Electric buses, EB battery, charging facility deployment, charging scheduling, robust optimization.

KNOWLEDGE GRAPH OF URBAN RAIL TRANSIT OPERATION INCIDENTS: CONSTRUCTION AND APPLICATIONS

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Urban rail transit is facing increasing operational incidents, which can significantly reduce passengers' mobility. Therefore, effective disruption management is crucial. However, due to burgeoning passenger flow and network complexity, the management of high-dimensional, intricately related multi-source data within urban rail transit systems poses a significant challenge. In this study, we introduce a knowledge graph-based framework to manage the multi-source data in urban rail transit systems, offering insights into the dynamics and impacts of incidents. The systematic procedures are composed of schema layer construction, knowledge extraction, knowledge fusion, and knowledge storage. Based on this knowledge graph, two specific applications are highlighted: firstly, the prediction of incident duration using a relational graph convolutional network (R-GCN) model, and secondly, the identification of affected origin-destination (OD) station pairs and passengers using a graphical method. These applications are tested and validated using a case study in Shanghai Metro. The results show the effectiveness of the knowledge graph in duration prediction, achieving an MRR of 0.89, and highlight the efficiency of the graphical method in identifying affected passengers, improving computational efficiency by 80% compared to relational databases. Our findings demonstrate the significant improvements made by knowledge graph in predicting and addressing disruptions, underscoring the potential of the knowledge graph-based approach in reshaping urban rail transit management strategies.

Keywords: Urban rail transit, operation incidents, knowledge graph, graph algorithm, detection of affected O-D pairs.

Abstract

ADAPTIVE SCHEDULING OF ELECTRIC BUS SERVICES WITH STOP-SKIPPING PATTERN USING A REINFORCEMENT LEARNING APPROACH

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This paper develops a real-time framework for electric buses operation with stop-skipping pattern. Operation of the bus services herein are driven by real-time passenger demand and specified by assigning service routes and deciding scheduling dispatch time. The optimization is formulated as a Markov decision process with capacity constraint. The control objectives include minimizing passengers' waiting times, passengers' in-vehicle times and buses' operation consumption. To address the computational challenges, we develop a deep reinforcement learning solution algorithm using the double deep Q network (DDQN) approach. The proposed computational framework is tested on a real-world scenario configured with the circulation route of Kowloon Motor Bus in Hong Kong. Experiments results illustrate the advantages of stop-skipping pattern in saving passengers travel time during the peak hour. This study contributes to the real time bus operation with control strategies and state-of-art optimization techniques.

Keywords: Electric buses, service scheduling, stop-skipping, Markov decision process, reinforcement learning.

SESSION B4: TRANSPORTATION NETWORK RECOVERY

RESILIENCE OPTIMAL-ORIENTED RESTORATION SCHEDULING OPTIMISATION FOR DISRUPTED TRANSPORTATION NETWORKS

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Restoration of damaged roadways in a transportation network under disruptions is of great importance to resume the operational function of the network. This paper proposes a resilience optimal-oriented bi-level mathematical modeling framework to identify the restoration scheduling of damaged links in urban transportation networks under disruptions. In the framework, the upper-level model is formulated as an integer programming model to describe the restoration scheduling of damaged links using a total travel time-based metric for measuring the resilience of the whole network. While the lower-level model is formulated as a user equilibrium considering the effects of travelers' attitudes towards travel time uncertainty on the network performance. The objective is to minimize the total resilience loss of the whole network. A heuristic-based optimization methodology is developed to obtain the near-optimal solutions to this problem. Finally, the applicability of this framework is demonstrated through a medium-sized numerical example. The results show that the proposed framework is effective in directing the resilience-optimal network restoration scheduling considering the effects of travel time uncertainty.

Keywords: Network reliability, scheduling, artificial bee colony algorithm.

SURROGATE MODELING FOR RECOVERY MEASURES OPTIMIZATION TO IMPROVE TRAFFIC RESILIENCE

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Transportation network disruptions (demand-side or supply-side disruptions) will significantly impair transportation efficiency. Given that the macroscopic fundamental diagram (MFD) is an intrinsic property of a homogeneously congested transportation network, this paper aims to create an MFD-based resilience optimization model to find optimal combinations of recovery measures for dealing with network disruptions. For evaluating MFD dynamics in different scenarios, stochastic traffic simulations are needed to generate relevant traffic information. Namely, traffic simulation is a component of objective function evaluation. In addition, a bunch of constraints are imposed on the optimization model to reach realistic decisions, such as financial and computational/time budget constraints. Therefore, a simulation-based surrogate model is developed together with an efficient solution algorithm named modified metamodel Adaptive Hyperbox Algorithm (modified MetaAHA). This model can serve as a practical tool to assist the design and implementation of local disaster preparedness and response mechanism. A case study is conducted in Munich, Germany.

Keywords: Surrogate model, traffic resilience, disruption recovery, macroscopic fundamental diagram, simulation-based optimization.

Abstract

INFERRING NETWORK CAPACITY REDUCTION AND DEMAND VARIATION AFTER DISRUPTIONS FOR RAPID SYSTEM EVALUATION

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This study develops a network assessment approach after network disruption, i.e., the joint estimation of network-scale road capacity reduction (CR) and origin-destination demand matrix (DM) (hereafter referred to as CRDM) for a given network subject to extensive disruption. In particular, the degree of road link degradation and locations of damaged links are unknown and have to be inferred subject to limited real-world data (e.g., some travel time observations based smartphone or other trajectory data). The CRDM problem involves a bi-level framework. We utilize both the general-least square model and maximum entropy principle to examine the solution properties such as existence, uniqueness, optimality conditions, and upper and lower bounds of the optimal solutions for the CRDM problem and investigate the effectiveness of the proposed method based on link travel time for rapidly estimating link capacity and OD-demand under different levels of observation and uncertainties which further illustrate the effectiveness of our proposed model.

Keywords: Network assessment approach, Joint estimation of road capacity reduction and origin-destination matrix, Bi-level optimization, Maximum entropy principle.

SESSION B5: STOCHASTIC TRAFFIC SIGNAL CONTROL

COORDINATED SIGNAL CONTROL UNDER STOCHASTIC TRAFFIC DEMANDS AND TURNING RATIOS CONSIDERING SPATIAL-TEMPORAL DEPENDENCIES

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Stochastic traffic demands and turning ratios are critical factors in coordinated traffic signal control. However, existing studies ignore the spatial-temporal relationship between the vehicle arrival pattern on the coordinated approach and the traffic volumes, signal timings at upstream intersections. Turning ratios are usually assumed to be deterministic. This study develops a two-stage stochastic programming model for two-way coordinated adaptive control under stochastic traffic demands and turning ratios. The vehicle delay and queue length formulations are developed considering spatial-temporal dependencies under under- and over-saturated traffic. A hierarchical multi-objective function is proposed to avoid over-saturated traffic and ensure operational efficiency. In stage one, a base signal timing plan (i.e., common cycle length, fixed offsets, and green times) is optimized to minimize the expected residual queue length and vehicle delay under stochastic scenarios. In stage two (i.e., each scenario), adaptive cycle lengths and green splits are determined according to the evolution of traffic flows on the coordinated roads under the constraints of the base signal timing plan. The proposed model becomes computationally intractable to solve as the variable space expands. The notion of Phase Clearance Reliability (PCR) is introduced to decouple the strong interaction between the two stages. The deterministic equivalent problem (DEP) of the proposed model in one signal cycle is modified to optimize the base signal timing plan for serving the stochastic arriving and turned vehicles up to certain PCR values. A PCR-based gradient algorithm is designed for solutions. The experimental results demonstrate that the proposed model can significantly decrease the overflow rate and the vehicle delay compared to the three benchmarks, including Synchro plan and Allsop plan.

Keywords: Two-way coordinated signal control, demand and turning ratio uncertainty, two-stage stochastic program, vehicle arrival pattern.

Abstract

STOCHASTIC PRIORITY-INTEGRATED COORDINATION FOR ARTERIAL SIGNAL CONTROL CONSIDERING UNCERTAINTY IN CONNECTED BUS OPERATION

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Advanced connected vehicle technologies allow real-time information exchange, which helps improve arterial signal coordination and transit signal priority (TSP) to enhance public transportation efficiency. TSP methods considering impacts on existing arterial signal coordination have been widely explored. However, existing signal coordination control methods rarely consider influences of TSP control on coordinated traffic. The uncertainty of bus operation leads to random TSP control in real-world applications. By considering stochastic TSP control at intersections, the background signal coordination plan can balance time resources between passenger vehicles and buses. This study proposes a stochastic priority-integrated signal coordination (SPIC) method, which includes a stochastic program to determine the arterial signal coordination control offline considering stochastic TSP control at intersections and a mixed-integer non-linear program to determine TSP strategies in real time under connected vehicle environment. The objective is to minimize the total delays of passenger vehicles and buses. A sample-average approximation method is utilized to deal with the uncertainty in bus operation. The cycle length and offsets are the decision variables in the offline optimization problem, whereas signal priority plans, together with bus arrival and departure times at and from intersections and stops, are the decision variables in the online optimization problem. A scenario-based heuristic algorithm is designed to solve the optimization problem efficiently. Numerical studies indicate SPIC can save 36% total delay and 56% bus delay compared to the original signal control. Sensitivity analyses show SPIC effectively reduces bus delays with fluctuations in bus travel time, bus dwell time, and passenger vehicle demands.

Keywords: Arterial signal coordination, transit signal priority, bus operation uncertainty, connected bus, stochastic program.

A REAL-TIME STOCHASTIC APPROACH TO LANE-BASED DELAY FORMULA FOR REAL-TIME ADAPTIVE SIGNAL OPERATIONS

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This study aims to construct a mathematical framework for developing a real-time stochastic approach to lane-based queue lengths and delay formulas to implement adaptive transition zones in the local reactive control policy in the hierarchical group-based ATCS. The primary contributions of the proposed architecture are as follows: 1. Stochastic volatility derived from uneven proportional lane uses between upstream and downstream detectors is introduced in formulating queue lengths and delay estimation methods at a signalized intersection. It contributes to adaptively adjusting a transition zone depending on the uncertainty of estimated queue lengths in an individual lane on a real-time basis. 2. Backward queueing propagation speed induced by vehicles under a multilane environment was considered to calculate lane-based delay using stochastic differential equations and proportional lane-uses for real-time estimation of lane-based queue lengths. 3. The max-pressure control policy is harmonized with the global adaptive optimization scheme in the hierarchical structure of ATCS. The semi-adaptive transition zone maximizes the flexibility and the efficiency of adjusting the duration of the current green signal according to the uncertainty in queueing formation patterns in the local reactive control policy based on the max-pressure theory.

Keywords: Lane-based control delay, incremental queue accumulations, stochastic queue estimations, Langevin equations, stochastic process.

SESSION C1: TRAFFIC FLOW AND CONTROL

STOCHASTIC LIGHTHILL–WHITHAM–RICHARDS TRAFFIC FLOW MODEL CONSIDERING CORRELATED RANDOM PARAMETERS

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Stochastic phenomena commonly exist in traffic dynamics. For example, traffic flow can vary with traffic density, and travel time may fluctuate within a certain range over the same period across different days. This stochasticity has received increasing attention. Numerous studies have focused on fundamental diagrams and microscopic traffic modeling; however, studies on macroscopic approaches are few. The Lighthill–Whitham–Richards (LWR) model is popular for macroscopic-level modeling owing to its simplicity and ability to effectively explain shock formation and propagation. However, it is deterministic and describes traffic dynamics as equilibrium values in the long run, regardless of stochastic variations. This study developed a stochastic LWR (SLWR) model to account for the uncertainties associated with traffic dynamics. The governing equation of the SLWR model is a conservation law formulated as a time-dependent stochastic partial differential equation. Free-flow speed and jam density were treated as random parameters and followed a bivariate normal distribution. Both parameters were validated via empirical analysis. The stochasticity was caused by the heterogeneity of drivers while holding individual drivers' behaviors constant, which makes the SLWR model more realistic than previous methods. A simulation experiment with a temporal bottleneck was conducted to observe the traffic evolution patterns. To obtain numerical solutions, a Monte Carlo scheme was used to obtain benchmark results for comparison; moreover, a dynamically bi-orthogonal (DyBO) method based on a spatial basis and a stochastic basis was combined with Taylor series expansion and multivariate Hermite polynomials to solve the resulting nonlinear problem involving correlations between random parameters. The SLWR model could effectively describe stochastic dynamic traffic evolutions, and the DyBO solutions could achieve an acceptable level of accuracy while saving substantial computation costs compared with the Monte Carlo method.

Keywords: Stochastic traffic flow modeling, correlated random parameters, dynamically bi-orthogonal, multivariate Hermite polynomials.

Abstract

INTELLIGENT TRAFFIC CONTROL WITH USE OF INTERNET-OF-THINGS AND REINFORCEMENT LEARNING TECHNOLOGIES

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This study presents an actor-critic deep reinforcement learning approach to integrate multiple adaptive traffic control methods for optimizing traffic performance. Traditionally, different traffic control methods have been studied independently, resulting in a lack of coordination between the road infrastructures supporting these measures and constraining the optimization potential of traffic performance. To address the current issue, we develop a centralized traffic control framework in which the decisions of signal phasing plan and network-wide speed limits are sought to minimize traffic delays on both urban roads and freeways. With a large amount of data to process and vast decision space in real-time, we introduce the actor-critic deep reinforcement learning solution framework to parameterize the traffic states and decision spaces by artificial neural networks. A deep deterministic policy gradient algorithm is proposed to train the artificial neural networks with the simulation data representing the network conditions and control settings before the actor-critic agent is applied for online control. To test and evaluate the performances of the proposed approach, we develop a microscopic simulation model on the Tung Chung Road network in Hong Kong via the SUMO platform. Numerical experiment results indicate that the proposed approach could deliver significant improvement in terms of computation efficiency and traffic performance metrics. This study contributes to the field of transport management by exploring the potential for improving coordination between different traffic control methods using advanced transport network modelling and optimization techniques.

Keywords: Deep reinforcement learning, actor-critic architecture, traffic congestion management, adaptive traffic signal control, variable speed limit.

INTELLIGENT INTERSCTION COORDINATION: A DYNAMIC CONTROL APPROACH FOR CONNECTED AUTONOMOUS VEHICLE TRAFFIC MANAGEMENT

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Connected and Automated Vehicle (CAV) technologies have the potential to revolutionize traffic control and intersection efficiency through the use of advanced communication, sensors, and algorithms. Through vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, CAVs can coordinate their movements in real-time, optimizing vehicle sequencing and reducing conflicts at non-signalized intersections. This enables vehicles to move more efficiently and fluidly through intersections, without the need to stop and wait for a signal to change, leading to lower emissions, increased intersection capacity, and enhanced traffic flow. Our paper introduces a novel dynamic control strategy based on ADP to minimize traffic delays while ensuring collision avoidance and safety for autonomous vehicles traversing signal-free intersections. Our approach facilitates real-time control of CAVs, enabling them to adapt to continuously changing traffic conditions and vehicle arrivals, making it more responsive and efficient compared to other methods that rely on predetermined or rolling horizon-based decisions.

Keywords: Adaptive traffic control, Markov decision process, approximate dynamic programming, connected automated vehicles, non-signal intersection.

SESSION C2: AUTONOMOUS VEHICLES

OPTIMAL DEPLOYMENT OF DEDICATED LANES FOR CONNECTED AND AUTONOMOUS VEHICLES IN MIXED URBAN TRAFFIC NETWORKS

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Numerous contemporary studies have posited that connected and autonomous vehicles (CAVs) hold the potential to substantially enhance traffic safety and augment efficiency. One widely-discussed approach to optimize CAV operations within urban traffic networks involves the implementation of dedicated lanes (DLs). This study aims to assist system planners in optimally deploying DLs within heterogeneous urban traffic networks, which comprise both CAVs and Human-Driven Vehicles (HDVs). In pursuit of this objective, we have introduced a multi-class dynamic traffic assignment framework that enhances network performance and offers insights into traffic dynamics. Additionally, our methodology considers dynamic routing behaviour while devising DLs, formulating and approximating the problem as a mixed-integer linear program (MILP). The resulting strategy delineates the temporal and spatial aspects of the deployment of DLs for CAVs, specifying the quantity and locations of these lanes. Subsequently, we assessed our framework using test-bed networks of varying sizes and demand profiles, evaluating the solution's quality and the model's adaptability to diverse traffic conditions. Our findings indicate that implementing DLs for CAVs can bolster vehicular throughput across the network while neglecting dynamic capacity variation in mixed traffic may yield misleading outcomes.

Keywords: Mixed-integer linear programming, dynamic system optimum, connected and autonomous vehicles, human-driven vehicles, dedicated lanes.

TRAFFIC ASSIGNMENT MODEL FOR MIXED FLOW OF UE-PRINCIPLED HUMAN DRIVEN VEHICLES AND SO-PRINCIPLED AUTONOMOUS VEHICLES WITH STOCHASTIC LINK CAPACITY

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Recently, Autonomous Vehicles (Avs) have been attracting more attention in the transportation studies. As Avs penetrate the road network, it is expected to result in a mixed driving environment of Avs and Human driven Vehicles (HVs). For considering the transportation system with such a mixed environment, traffic assignment model that takes the characteristics of the mixed flow into account is necessary. Since Avs can share the information of its velocity and acceleration, they may be able to move more efficiently than HVs. Further, Avs can also share the information with infrastructures. It can provide a fertile ground to push for a more efficient traffic circulation such as System Optimal (SO). Therefore, it is necessary for the forthcoming penetration of autonomous vehicles to develop traffic assignment models that take into account the heterogeneity both in microscopic traffic flow due to differences of vehicle moving and in macroscopic traffic flow due to differences of the route choices. This study proposes a multiclass traffic assignment model for the mixed flow by considering the stochastic road capacity resulting from the heterogeneous headways, and vehicle SO principled Avs and UE principled HVs.

Keywords: Multiclass traffic assignment, autonomous vehicle, mixed flow, stochastic road capacity.

Abstract

SHARED AUTONOMOUS VEHICLES PREFERENCE INVESTIGATION CONSIDERING RELIABILITY AND PSYCHOLOGICAL FACTORS IN A CAMPUS ENVIRONMENT

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This paper investigates the user's preference for shared autonomous vehicles (SAV) by survey in a campus scenario. The data was collected by revealed preference (RP) and stated preference (SP) survey, combined with a nested logit model, which correct the bias of SP data and improve the regression preference. The results revealed the importance of the reliability of SAV services and the extra waiting time may lead to the decline of traffic mode occupancy. Besides, the respondent performs extremely higher demand and interest in personalized travel services than fixed ones.

Keywords: Traffic survey, traffic mode split, shared autonomous vehicles, reliability, psychological preference.

CUSTOMER CENTRIC & SMART RAILWAY MOBILITY

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Customer-and-community centricity is always in the heart of MTR. We are committed to continuously enhancing customer experience through digitalization and innovation. After the full line opening of Tuen Ma Line in 2021 and opening of East Rail Line (EAL) Cross-Harbour Extension in 2022, there are more alternative routes for passengers to travel. Moreover, Admiralty Station becomes a super transit hub comprising of 4 lines (i.e. Tsuen Wan Line, Island Line, South Island Line and the extended East Rail Line). Riding on this opportunity, we have launched the following digital initiatives to further enable and enhance smart mobility with two major focuses: 1) Customer Experience with Digitalization: Train Car Loading Indicator for Tuen Ma Line and East Rail Line, Waiting Time Indicator at Major Interchange Stations, Cross-Harbour Easy at Admiralty Station. 2) Operations Management with Innovation and Technology: Train Operation Log Analysis Dashboard. All the above initiatives enable smart mobility with customer-centricity, providing seamless and hassle-free services to customers and communities.

Keywords: Innovation; smart mobility; railway; data analytics; customer experience.

SESSION C3: TRANSPORT RESILIENCE

ASSESSING ZONAL RESILIENCE: A STUDY ON THE IMPACT OF DAY-TO-DAY DISRUPTIONS ON THE ROAD NETWORK

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Road networks are often subjected to day-to-day disruptions, such as higher congestion caused by demand and traffic flow fluctuations. A perfectly resilient road network will be able to absorb and recover quickly from such disruptions. However, the transport network is only partially resilient; certain road links recover quickly, while others take longer to recover. This difference in resiliency can be due to zonal characteristics, network structure, or other factors. Thus, this study aims to develop a methodology for quantifying the impact of flow variation on zonal-level resilience and identify the factors that affect it. For quantifying the resilience, crowdsourced traffic speed data for more than 30000 locations have been used. This data has been used to develop a Zonal Resilience Index (ZRI), a function of the average performance loss of different road categories. Using Pearson's correlation, the ZRI has been correlated with zonal node density, road length density, bus stop density, road category, land use entropy, and other demographic and socio-economic factors. The results of correlation analysis showed that zonal node density, road length density, and bus stop density have a strong negative correlation with ZRI. The population density also shows a strong negative correlation. However, the income-related metrics did not correlate with ZRI.

Keywords: Transport resilience, road network, zonal resilience, performance loss, disruptions.

EVALUATING THE COMMUNITY RESILIENCE: A COMMUNITY-BASED PEER-TO-PEER RESOURCE-SHARING FRAMEWORK

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Evaluating community resilience is crucial for disaster preparedness. Previous studies have mainly focused on the impact of pre-planned measures, such as emergency resource centers, and have overlooked the value of spontaneous resource sharing within a community. This study aims to evaluate the potential of peer-to-peer (P2P) resource-sharing behavior on community resilience. Using survey data collected from the Laurelhurst neighborhood in Seattle, Washington, this study first generates realizations for the community-based social network, households' willingness to share, and resource inventory. A P2P resource-sharing model is then presented to simulate sharing behavior within the community. Finally, the expected survival rate and α-quantile survival rate metrics are used to analyze the impact of P2P resource-sharing on community resilience. The results demonstrate that this framework is capable of providing valuable insights into community-based P2P resource sharing and has the potential to enhance disaster management efforts.

Keywords: Community resilience, peer-to-peer, resource sharing, social ties, social network.

Abstract

SENSITIVITY-BASED APPROACH FOR CONGESTED TRANSIT ASSIGNMENT ON SKIP-AND-STOP METRO SYSTEM

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In this study, we modeled the user behavior of the skip-and-stop train system from a microscopic perspective and optimized the system operation schedule. Passenger groups identify the optimal route through disutility by route, and some passengers bypass the non-congestion route to avoid in-vehicle congestion. This behavior is reinforced by the increasing importance of in-vehicle congestion as the parameter increase. When the parameter level increases, in-vehicle congestion's importance is emphasized. As the parameter increase, the overall travel time also increases, and system performance is worsen. Through this study, we can identify the impact of passengers' sensitivity to in-vehicle congestion on the system retrofit problem. This result suggests the possibility of schedule optimization considering the influence of bypass passengers. In addition, a travel time conversion value for in-vehicle congestion may be estimated through sensitivity between in-vehicle congestion and travel time. The full paper presents the trend of the disutility of each train type according to the level of in-vehicle congestion recognition and the change in in-vehicle congestion according to the parameter level. It also includes changes in passenger-specific benefits and side benefits, the bypass rate for non-congested routes according to schedule changes.

Keywords: Skip and stop metro system, congested transit assignment, route choice behavior, in-vehicle congestion, schedule optimization.

SESSION C4: BIG DATA AND TRANSPORTATION

TRAFFIC UNCERTAINTY PREDICTION WITH A HYBRID KALMAN FILTER BASED DEEP NEURAL NETWORK

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Providing the statistical description of uncertainty along with the state prediction of traffic variables is crucial to the intelligent transportation system. However, the widely adopted Kalman filter prediction often experiences difficulties in obtaining accurate estimates of noise covariance matrices, leading to performance degradation. In this paper, we present a novel approach for multivariate uncertainty traffic prediction using a hybrid model-based and data-driven framework without explicit knowledge on the underlying dynamics of the traffic system. The model-based component applies the dynamic linear regression statistical method to get the prior estimations of multivariate traffic variables. The data-driven component uses four Gated Recurrent Unit cells to track changes in second-order statistical moments independently. These cells are interconnected by fully connected layers based on the calculation flow of the Kalman filter. The entire proposed model is trained using a Gaussian negative log-likelihood loss function, which allows us to obtain explicit uncertainty estimates represented as time-varying error covariance matrices. The proposed framework is implemented and tested on a real Hong Kong highway corridor with actual data collected from the field. The numerical study shows that the proposed hybrid model can simultaneously retain the interpretability of the statistical model and learn complex uncertainty from the data. This study contributes to the development of reliability-based intelligent transportation systems through the use of advanced statistical modeling and deep learning methods.

Keywords: Multivariate uncertainty, Kalman filter, deep learning, error covariance.

A DATA-DRIVEN APPROACH FOR URBAN ROAD NETWORK RESILIENCE ASSESSMENT: INTEGRATING SPATIOTEMPORAL ANALYSIS WITH RESILIENCE TRIANGLE CONCEPT

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This paper presents a data-driven approach for investigating the spatiotemporal impact of daily non-recurring disruptions and resilience of urban road networks. The underlying traffic propagation dynamics and recovery time, vulnerability, and resilience of an urban road network are examined using multi-year observed travel time and incident data. The study develops a statistical method to estimate event occurrence, restoration, and recovery times, while also formulating a new resilience metric inspired by the resilience triangle concept and complex network theory. The analysis captures the microscopic dynamics of affected road links in detail and allows for an accurate estimation of the incident's occurrence, restoration, and recovery times. The results indicate that incidents are often detected earlier than reported, but the impact of those incidents remains on the network for a longer period than reported. In addition, areas with low resilience tended to be geographically clustered, often near high-demand regions with low network density, indicating inefficiency in the network and low resilience. It is demonstrated in this study that the proposed methodology is capable of capturing network response to disruptions accurately and providing valuable insights for transport policy, including the strategic placement of recovery resources, such as police units, during disruptions. The findings of this study have significant implications for the improvement of urban road network resilience.

Keywords: Network resilience, data-driven approach, spatiotemporal analysis, resilience triangle, complex network theory.

Abstract

MODELLING NETWORK-WIDE TRAFFIC CONDITION ESTIMATION CONSIDERING UNCERTAINTIES AND SPARSE MULTI-TYPE DETECTORS

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Accurate monitoring and sensing network-wide traffic conditions under uncertainty is vital for addressing urban transportation obstacles and promoting the evolution of intelligent transportation systems (ITS). Owing to fluctuations in traffic demand, traffic conditions exhibit stochastic variations by the time of day and day of the year. The joint estimation of stochastic speed and flow is pivotal in ITS, drawing on the symbiotic relationship between these two variables to furnish comprehensive insights into traffic conditions. Nevertheless, constraints such as budgetary limitations and physical boundaries render the coverage of traffic detectors both sparse and inadequate, thereby complicating the precise assessment of network-wide traffic speeds and flows in uncertain scenarios. To address this challenging problem, this paper proposes a novel network-wide traffic speed-flow estimator (SFE) grounded in the Kullback-Leibler divergence optimization method. This SFE harnesses data derived from sparse multi-type detectors, such as point detectors and automatic vehicle identification sensors. Significantly, it leverages the statistical correlation relationships (i.e., covariance matrix) of the speed and flow between observed and unobserved links to estimate stochastic speed and flow on unobserved links (i.e., the links without traffic detectors). In addition, fundamental diagrams, modeling the interdependence between link speeds and flows, are incorporated as constraints in the proposed SFE model. This inclusion markedly diminishes discrepancies and elevates estimation precision relative to individual assessments of speeds and flows. Numerical illustrations, encompassing both simulated and real-world road networks, validate the enhanced performance and applicability of the proposed SFE model, suggesting its potential role in augmenting data robustness within ITS.

Keywords: Speed–flow estimator, KL divergence, variance–covariance relationship, fundamental diagrams, intelligent transportation systems.

SESSION C5: PUBLIC TRANSPORTATION II

ROBUSTNESS OF ON-DEMAND PUBLIC TRANSPORT NETWORKS FROM A RANDOM NETWORK PERSPECTIVE

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This paper investigates the robustness of on-demand public transport networks, characterized by an uncertain topology that poses challenges for robustness assessment. We construct a random multilayer public transport network, where each layer represents a transit line with a route ensemble determined using constraint programming. From the perspectives of complexity, flexibility, and redundancy, we develop eight topological metrics to measure network robustness. Additionally, we conduct network attack simulations to derive 12 simulation-based robustness indicators, considering network performance measures of the size of the largest connected component and global network efficiency, attack strategies of targeted attack and random failure, and various critical thresholds on the performance curve. Correlation analysis between the proposed metrics reveals a positive relationship between the topological properties and network robustness, validating the effectiveness of the topological metrics in assessing the robustness of networks with uncertain topology. This study fills a gap in the existing literature by providing a robustness analysis framework specifically tailored to on-demand public transport networks, contributing to the design of more resilient on-demand public transport systems.

Keywords: Robustness, public transport network, on-demand, random network, multilayer network.

OPTIMAL SEAT OCCUPANCY OF CUSTOMIZED BUS SERVICES CONSIDERING IN-VEHICLE INFECTION RISK COST DURING PUBLIC HEALTH EMERGENCIES

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Customized buses (CB), offering personalized route and reserved seat arrangements, meets the diverse travel needs of passengers. However, usage of public transit dropped significantly during COVID-19 epidemic due to concerns of in-vehicle infection. To address the need of determining optimal operation strategies during the epidemic to raise profit while maintaining rational in-vehicle infection risk, this study proposes a bi-level operation strategy optimization model which integrates the W-R equation to measure in-vehicle infection risk. The upper-level model optimizes seat occupancy rate to maximize profit while penalizing total infection risk of CB. The lower-level model is the logit mode choice model considering infection risk cost. Results underline the necessity to consider infection risks associated with different travel modes when planning CB operation strategies. Results also show that infection control can be effectively achieved by optimizing seat occupancy.

Keywords: Customized bus, optimal occupancy rate, infection risk, public health emergencies.

Abstract

IMPACT OF WEATHER ON PUBLIC TRANSPORT: A STUDY OF BUS RIDERSHIP IN THE WEST MIDLANDS OF THE UK USING SMART CARD DATA

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By understanding the relationship between weather conditions and public transport ridership, transport authorities can implement targeted measures to optimize service and enhance the overall experience of public transport users. This study explores the impact of weather conditions on bus ridership in the metropolitan area of West Midlands, UK, using six years of hourly smart card data and weather station records. We employed the matched-pair method to investigate how weather variables affect bus ridership for different passenger groups, including commuters, students, children, elderly and disabled people. Our analysis primarily focused on the influence of temperature and precipitation on travel behaviors of bus users and ridership patterns. The analysis results indicated that, generally, precipitation impacted the ridership of all passenger groups, while temperature appeared to negatively influence the travel habits of commuters, students and children. Furthermore, we examined thermal comfort indexes (e.g., heat index and apparent temperature), which better describe the heat effect and represent people's true perceptions of thermal conditions. Students and children were found to be the most temperature-sensitive passenger groups, likely due to their frequent use of open-air travel modes for a substantial portion of their trips. These findings shed light on the weather's influence on public transport usage and can guide the development of policies to improve public transport service and accommodate the specific needs of different passenger groups. The insights contribute to creating a weather-resilient public transport system that better serves the diverse needs of passengers in the local area.

Keywords: Public transport, weather changes, bus ridership, smart card data, travel behavior.

SESSION D1: TRANSPORTATION NETWORK RESILIENCE I

A NETWORK FLOW APPROACH FOR MODELLING CONCURRENT RESTORATION PROBLEM

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The collapse of critical facilities may significantly affect the connectivity of infrastructure networks, underlining the need for timely and efficient restoration activities. In the aftermath of the disruptions, the system performance will gradually increase to the pre-disaster state with the sequential recovery of the blocked facilities. This paper intends to focus on the concurrent restoration problem that allows for multiple blocked facilities restored in parallel. The crucial issue is to determine the start time of the restorations and keep track of the state variation. To this end, this paper proposes a general network flow approach to identify the concurrent restoration sequence. Firstly, an adaptive network generation process is developed, where the state of nodes and the weight of edges are updated in a dynamic process. On the basis of the generated flow network, an exact solution can be effectively obtained from the shortest path in this network, instead of using metaheuristic algorithms to solve a complex combinatorial mathematical model. Several numerical examples are presented to demonstrate how the concurrent restoration problem can be efficiently solved by the proposed network flow approach.

Keywords: Community resilience, peer-to-peer, resource sharing, social tie, social network.

ASSESSING AND IMPROVING TRANSIT SYSTEM REDUNDANCY WITH NETWORK WIDE CAPACITY

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Transit system redundancy plays an important role in determining the capability of transit systems to withstand disruptions. This paper proposes measuring transit system redundancy with a network-wide performance indicator, i.e., transit network spare capacity, which reflects how much additional demand (i.e., passenger flow) can be accommodated by the transit network. By evaluating transit system's backup capacity for serving travel demand, this indicator can effectively measure the preparedness of the transit system for unexpected disruptions. Typically, network capacity assessment with explicit behavioral considerations needs to deal with a bi-level mathematical program, which however suffers from the computational intractability issue. To overcome this challenge, this paper develops a single-level variational inequality approach that can evaluate transit network capacity by tackling a sequence of elastic-demand transit equilibrium problems in the frequency-based assignment framework. In addition, considering that the network capacity can flexibly account for supply-demand interactions, this paper will provide a variety of viable measures to improve transit network capacity from both supply (e.g., increasing line frequency to enhance the capacity of lines) and demand sides (e.g., adjusting transit fares to regulate travelers' choice behavior). Numerical experiments are conducted to verify the efficiency of the evaluation approach and to examine and compare the effectiveness of different improvement measures.

Keywords: Transit, redundancy, network capacity, variational inequality, transit assignment.

Abstract

MODELING ADAPTIVE CAPACITY OF TRANSPORTATION NETWORK

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This study aims to conceptualize the adaptive capacity, which is one of the important functions of system resilience but has received little attention in the context of transportation networks. We first distinguish adaptive capacity from other existing concepts associated with the more often visited absorptive and restorative capacities, which may facilitate the understanding and enhancement of transportation resilience. A quantitative measurement based on the network capacity is proposed to analyze adaptive capacity at the network level. The effects of adaptation to external stresses are considered from different perspectives to provide a complementary view of the inherent adaptability of transportation networks. A bi-level model is then developed to analyze network adaptive capacity while considering the congestion effect on equilibrium adaptation choice behavior.

Keywords: Adaptive capacity, resilience, adaptation stress, network capacity model.

SESSION D2: SHARED MOBILITY

MULTI-PLATFORM GAME AND OPERATION OF EBIKE-BIKE SHARING SYSTEMS BASED ON REINFORCEMENT LEARNING

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The introduction of ebikes brings new competition and opportunities to bike-sharing markets. It is challenging for platforms to determine the allocation and price of ebikes for complex interactions between ebikes and bikes and unpredictable decisions of competitors. This study addresses the operation (i.e., gaming) of ebike-bike sharing systems in a duopoly market. We establish a Markov Decision Process (MDP) model accounting for interactive effects among one mainstream platform, one completing platform, and the passengers, and adopt a dynamic gaming framework to characterize the decision-making processes of heterogeneous platforms. Reinforcement learning-based decision optimization methods are designed. Numerical studies are conducted based on the real dataset in Shenzhen and the win-win situation is achieved.

Keywords: Ebike-bike sharing system; multi-platform; reinforcement learning; dynamic pricing.

RISK-AVERSE DYNAMIC SYSTEM OPTIMAL TRAFFIC ASSIGNMENT FOR RIDE-SHARING SYSTEMS

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This study explores the theoretical properties of vehicle-passenger assignment for ride-sharing that achieves the dynamics system optimum (DSO) in a parallel network with stochastic travel time. The parallel network comprises three links; the first is an HOV link with a single bottleneck, the second represents a general purpose (GP) link that can be considered an aggregate of other road networks, and the third is a public transit link for non-ride-sharing passengers. We assume the following scenario; only ride-sharing and non-ride-sharing vehicles are allowed to pass the HOV and GP links, respectively. This problem can be formulated as a stochastic optimal control problem. Traffic supply (vehicles) and demand (passengers) are assigned to each link such that the total system cost is minimized. The optimality conditions reveal DSO assignment patterns and some qualitative properties of risk-averse DSO assignments.

Keywords: Ride-sharing, dynamic traffic assignment, system optimum, stochastic control, risk-averse.

Abstract

OPTIMAL COMPENSATION SCHEME DESIGN FOR INTEGRATIVE SHARED MOBILITY SERVICES

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This study aims to investigate the optimal compensation scheme design for integrative shared mobility (ISM) services that use an on-demand shared vehicle fleet to provide both passenger ride and parcel delivery services. Vehicles are allowed to pick up or drop off parcels or other passengers with some passengers already on board. The ISM service operator will offer a certain amount of compensation to the onboard passengers for the extra ride duration (ERD). We formulate a two-stage stochastic programming model under stochastic passenger and parcel transportation demands by considering the operational vehicle routing and the passengers' nonlinear acceptable excess ride duration (AERD) profile, indicating their willingness to tolerate the ERD based on the amount of compensation offered. To solve the problem, we propose a customized ALNS-CSA algorithm that incorporates an adaptive large neighborhood search (ALNS) heuristic and an efficient compensation scheme adjustment (CSA) method to obtain the optimal compensation scheme in an iterative manner. The ALNS heuristic is employed to determine the optimal demand serving, passenger compensation, and vehicle routing (DPV) solution of each scenario while relaxing the complex non-linear AERD constraints. The CSA method further adjusts and improves the compensation scheme according to the newly-generated DPV solutions to resume the feasibility with respect to passengers' AERD constraints while minimizing the compensation cost. Numerical experiments are carried out to evaluate the performance of the model and solution method. Impact analysis is also conducted to explore the effectiveness of this new business model and derive valuable managerial insights.

Keywords: Integrative shared mobility, compensation scheme, stochastic demand, hybrid algorithm.

SESSION D3: LOGISTICS AND SUPPLY CHAIN II

AN EXTENDED SMART 'PREDICT, AND OPTIMIZE' (SPO) FRAMEWORK BASED ON SIMILAR SETS FOR SHIP INSPECTION PLANNING

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This study addresses a ship inspection planning problem which aims to select a set of ships among all the foreign visiting ships for inspection. We consider a critical decision problem: from a set of I foreign visiting ships, select N ships with the highest risks for inspection to maximize the inspection benefit. In the first stage, ship deficiency number is predicted using machine learning models considering various features. Then, in the second stage, the top N ships with the largest predicted number of deficiencies among a set of I foreign visiting ships are selected. In this study, we choose decision tree (DT) as the prediction model. Especially, the traditional CART based DT algorithm is used to construct DT of mode 0. In DT of mode 1, similar sets generated from the decision problem are used for hyperparameter tuning after constructing a traditional DT. In DT of mode 2, similar sets are used in both the DT construction process and the hyperparameter tuning process. In DT of mode 3, weighted performance of the following decision problem is directly used to guide DT construction and hyperparameter tuning. Numerical experiments using real inspection data at Hong Kong show that DT in mode 1, mode2, and mode 3 can improve DT in mode 0 (which is the traditional DT construction mode) by 7.48%, 0.91%, and 10.66%, respectively.

Keywords: Ship inspection planning optimization, predict and optimize models, smart 'predict then optimize' (SPO), prescriptive analytics.

USING TWITTER DATA TO ESTIMATE TRUCK DELAY COSTS DUE TO MOTOR VEHICLE COLLISIONS ON RURAL HIGHWAYS IN ALBERTA, CANADA

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Economy of Canada is depended on truck industries to ship goods and material through its vast land. Any event that causes delays or closures on transportation networks can impose extra cost on trucking industries, such as Motor Vehicle Collisions (MVCs). In order to be able to estimate the cost imposed on these industries, data is needed. Social network contents are becoming valuable sources of data, but we need methodologies to harness their powers in spatial analysis. Therefore, in this study, first we proposed a methodology to extract geographical information from textual content of Twitter platform. Then, the methodology was used to extract MVC events in Alberta, Canada. In the next step, this data source was used to develop three scenarios to investigate how much MVCs cause imposed costs on trucking industries. Results of geocoding Twitter reports indicated that the methodology could geocode 85% of tweets in a distance less than 20 km away from their actual locations. Moreover, results of the developed scenarios helped us identify critical highway traffic control sections for trucking companies.

Keywords: Social networks, twitter, motor-vehicle collision, trucking industry, criticality, geographical information science.

Abstract

EMERGENCY RESPONSE RESOURCE ALLOCATION CONSIDERING VEHICLE TYPES

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An essential aspect of Emergency Medical Services (EMS) is the effective allocation of ambulance resources, which can greatly influence patient outcomes. Key to this is the dispatch policy for ambulance deployment, and the question of whether ambulances, specifically designed for certain types of incidents, should be assigned to other types of emergencies as well. This research uses a simulation-based model to investigate this question, with the aim of identifying the most efficient policy for ambulance resource allocation that would yield optimal patient outcomes. The model considers multiple types of emergency vehicles, the distribution of emergency incidents, and the evolution of incident processing. The experimental results demonstrate that the deployment of advanced ambulance vehicles can enhance the survival rates of emergency incidents, particularly those corresponding to the vehicles' intended function. This study proposes a simulation framework and methodology that could be adapted to other geographical regions, thus offering a versatile tool for evaluating the potential benefits of deploying advanced emergency vehicles.

Keywords: Emergency medical services, ambulance dispatch, vehicle types, reassignment and reallocation, survival rate.

SESSION D4: BUS OPERATIONS

THE ROLE OF RIGHT TURNS IN BUS OPERATION

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In a previous study, we found that bus and transit lanes (known as Transit Lanes in Australia) were effective priority measures for improving bus reliability. When controlling for the presence of bus lanes, higher values for traffic volume, number of traffic lights and right turns (left turns for right-hand drive) all contribute significantly to bus unreliability during operation. Utilizing the GTFS-R trip update and vehicle position data, we conduct a microscopic analysis of the effect of right turns on bus operation. First, we establish the statistical significance of right turns in increasing mean delay and standard deviation of delay. Then we present an analysis of the vehicle speeds and trajectories in the right turns local environment to understand the delay's cause. Finally, two cases in Sydney where relevant intersection-focused bus right-turn priority measures can be implemented are examined. For the first intersection with three right turn lanes, a queue jump lane was implemented. For other intersection with limited space, a novel bus right-turn priority measurement, the bus right turn priority box, was implemented, which is an in-lane right-turn queue jump lane. We anticipate recommendations for considering micro-scale factors affecting bus operations and that the proposed intersection-focused priority measures can improve bus reliability in routes with right turns.

Keywords: GTFS-R, bus operation, bus reliability, bus priority, microscopic analysis.

INTEGRATION OF FLEXIBLE BUS AND PARCEL DELIVERY UNDER STOCHASTIC DEMAND AND SERVICE TIME

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The growth of e-commerce has increased pressure on urban freight systems, worsening traffic congestion and increasing environmental costs. To address this issue, we propose a flexible transportation system that integrates both passenger and parcel services. A stochastic optimization model is developed that considers random spatial distribution, service time, and demand volume of orders to solve the routing and order assignment problem for the integrated system. The flexible bus routes are planned in the first stage and actual passenger and parcel service requests are assigned to each bus in the second stage. To solve the problem, a reliability-based decomposition method is proposed, and gradient descent is applied to optimize the reliability to obtain the optimal flexible bus route for minimizing the cost. An illustrative example showed the efficiency improvement. By implementing this system, both passengers and freight can benefit from the systems efficiency. The proposed system contributes to mitigating congestion, reducing environmental costs, and better utilizing vehicle space. It has the potential to benefit both passengers and parcel delivery to meet the challenges of urban logistics.

Keywords: Co-modality, stochastic programming, reliability, flexible bus, parcel delivery.

Abstract

BUS ROUTING-SCHEDULING DESIGN UNDER STOCHASTIC DEMAND

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To improve the reliability of the public transport (PT) service, this paper proposes a PT mode that considers both regular and flexible services under stochastic demand. The flexible service is introduced to address the excessive demand that the regular service cannot satisfy. A two-stage stochastic programming model is developed to jointly optimize the routing and scheduling decisions for the PT service. The first stage is to solve the problem of bus route design and determine the optimal bus routing as the baseline plan. After realizations of the random demand, the second stage is to optimize the scheduling scheme for regular and flexible buses. The multi-depot vehicle scheduling problem under different demand scenarios is developed. The overall objective is to minimize the expected system cost. For computation efficiency, the intertwined two-stage problem is decomposed into two independent sub-problems by introducing the concept of service reliability (SR). Then, a SR-based gradient descent algorithm is used to derive the optimal SR. The proposed method is validated through numerical experiments on an actual bus route in Shenzhen. Sensitivity analysis is conducted considering the impact of demand variations on the system performance. The results indicate that compared with deterministic methods, the proposed SR-based stochastic method can maintain lower system cost under demand uncertainty.

Keywords: Bus routing-scheduling, flexible transit service, stochastic programming, service reliability.

SESSION E1: EVACUATION AND DISASTER RELIEF II

SIMULATING PEDESTRIAN EVACUATION IN HALL USING ARTIFICIAL INTELLIGENT ALGORITHM

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Aiming at the problem of crowd evacuation in hall, we propose a pedestrian evacuation model in large hall based on floor-field theory and using intelligent algorithm. First of all, considering that the layout of the large hall is critically linked to the evacuation time of the crowd and public safety, the article sets different exit and obstacle locations. Secondly, pedestrians generally have a destination, setting the static floor-field formed near the exit. It doesn't change over time and isn't evolve with the movement of the pedestrian. Finally, the pedestrians will avoid entering high-density region during the movement, the dynamic floor-field is calculated by using the dynamic density of nearby pedestrians. The pedestrian transition probability can be calculated according to the static and dynamic floor-field. At the same time, we combine artificial intelligent algorithm such as machine learning and particle swarm algorithm to simulate crowd behaviour. The results indicated that different exit and obstacle Settings have an important relationship with the behaviour during evacuation of crowd. Considering the dynamic floor-field, pedestrians enter the high-density cell with a low probability, which can effectively avoid the congestion and considering the intelligent algorithm can reduce the pedestrian evacuation time.

Keywords: Pedestrian evacuation, artificial intelligent algorithm, floor-field theory.

ENDOGENOUS STOCHASTIC EVACUATION OPTIMISATION FOR DRONE-ASSISTED EVACUATION

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Evacuation is a crucial process in minimizing loss of life during disasters. However, for unpredictable disasters like earthquakes, effective evacuation strategies are hindered by the uncertainty of infrastructure damages, which affect routing decisions for evacuees. Recent advancements in Unmanned Aerial Vehicle (UAV) technology and manufacturing costs have led to increased interest in integrating UAVs into disaster response. Although previous studies have focused on damage analysis and assessment, no research has evaluated the potential of UAVs in facilitating evacuation. This study develops an endogenous stochastic mathematical model, in which UAVs explore the network to assess damages and advise evacuees on safe routes. An agent-based model (ABM) is created which considers the effect of evacuees following government advice and social pressure in their decision-making during evacuation. This ABM serves as the environment for a deep Q-learning model, which optimizes UAV deployment for damage assessment.

Keywords: Endogenous stochastic optimization, evacuation, disaster response, reinforcement learning, unmanned aerial vehicle.

Abstract

EQUITABLE SEQUENCE TO RESTORE TRANSPORTATION NETWORK LINKS AFTER EXTREME DISASTER

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This study focuses on post-disaster response through urban network restoration plan. Assuming adaptive user behavior in response toward each recovery progress, our major objectives is to maximize the system's efficiency whilst take into account equity into formulation. We construct MIP model as a deterministic solution as well as novel non-deterministic strategies to comply with pareto improvement. Our non-deterministic proposals demonstrate successful implementation at least for our testing network although coming with its limitation mostly between the trade-off between computational time and robustness for each strategy.

Keywords: Post-disaster recovery, road network, equity.

SESSION E2: RAIL SYSTEM VULNERABILITY

EVALUATING THE FLOODING LEVEL IMPACTS ON URBAN METRO NETWORKS AND TRAVEL DEMAND: BEHAVIORAL ANALYSES, AGENT-BASED SIMULATION, AND LARGE-SCALE CASE STUDY

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Weather events such as heavy rainfall and flooding impacting the metro system services are becoming increasingly of concern. Plans for such emergency interruptions require a thorough understanding of the potential outcomes on both the system and individual component scales. However, due to the complex dynamics, constraints, and interactions of the elements involved (e.g., disaster, infrastructure, service operation, and travel behavior), there is still no framework that comprehensively evaluates the system performance across different spatiotemporal scales and is flexible enough to handle increasingly detailed travel behavior, transit service, and disaster information data. Built on an agent-based model (ABM) framework, this study adopts a data-driven ABM simulation approach informed by actual metro operation and travel demand data to investigate the impact of flood-induced station closures on travelers as well as the overall system response. A before-after comparison is conducted where the traveler behaviors in disaster scenarios are obtained from a discrete choice model of alternative stations and routes. A case study of the Shanghai Metro is used to demonstrate the ability of the proposed approach in evaluating the impacts of flood-induced station closures on individual traveler behavior under normal operation and a series of water level rise scenarios of up to 5m. It was found that, when the flood-induced station closures only affect a few river-side stations in the city center, the travelers experience only minor disruptions to their trips due to the availability of unaffected stations nearby as a backup. However, as the water level increases and more stations (mainly in the suburban area) are affected, up to 25% of trips are no longer being fulfilled due to the loss of entrances, exits, or transfer links. The system experiences overall less crowdedness in terms of passenger volume and platform waiting time with a few exceptions of increased passenger load due to concentrations of passenger flows to alternative stations under flooding-induced station closures. The proposed approach can be adapted to other disaster scenarios to reveal the disaster impacts on both aggregated and disaggregated levels and guide the design of more spatio- and temporally-targeted emergency plans for metro systems.

Keywords: Metro flooding; infrastructure resilience; extreme climate events; agent-based simulations.

Abstract

THE VULNERABILITY EVALUATION OF METRO STATIONS – A CASE STUDY IN WUHAN, CHINA

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To evaluate the vulnerability of metro stations and ensure the metro systems stable operation, we take the Wuhan metro system as an example, analyzing the causes of metro disruptions and their development processes, and identifying the vulnerability factors from four perspectives of human, environment, equipment and management. The evaluation system contains 29 indicators and is constructed based on the Pressure-State-Response (PSR) model. Combining the Analytic Hierarchy Process (AHP) and entropy weight method to determine the indicator weight and the value of each indicator, the station vulnerability evaluation method is constructed based on the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) approach. All stations of lines 1, 2, 4 and 3 in the Wuhan metro system are selected for the case study, calculating their vulnerability scores. The results indicate that: from the line perspective, the stations in Wuhan metro lines 1 and 2 are more vulnerable. From the station perspective, Jianghan Road, Jiyuqiao and Zongguan are the top three stations with the highest vulnerability scores; generally, the vulnerability of elevated stations and interchange stations is higher than its counterpart of the other ordinary stations. From the region perspective, the metro stations located in administrative regions of Jianghan, Jiang'an and Wuchang, i.e., those close to the Yangtze River, are more vulnerable. These research findings can shed light on metro management, such as planning countermeasures to ensure the reliability of metro operations.

Keywords: Urban rail transit, metro disruptions, vulnerability evaluation, Pressure-State-Response model, combination weighting.

UNDERSTANDING EVOLUTION OF URBAN RAIL TRANSIT SYSTEM VULNERABILITY UNDER NETWORK EXPANSION: A CASE STUDY OF HONG KONG MTR NETWORK

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This study focuses on the evolution of vulnerability envelope with the expansion of URT network based on route redundancy measure. A case study based on the Mass Transit Railway (MTR) network in Hong Kong, is conducted to gain essential insights from real-world practices. By investigating the vulnerability envelopes in different development phases of the Hong Kong MTR network, this study is expected to enhance the understanding of how the vulnerability of URT system evolves with the changing network topology under network expansion. The empirical findings of this study may also provide some insights for planners on the robust topology and sequence of constructing new and extending existing rail lines in developing URT systems.

Keywords: Vulnerability envelope, route redundancy, simultaneous infrastructure disruption, Beijing subway network.

SESSION E3: TRANSPORTATION NETWORK RESILIENCE II

HOW THE RISE OF TRUCKS HAS REDUCED NETWORK TRAFFIC THROUGHPUT

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This paper collects the morning peak period data of 564 loop detector stations across the Minneapolis – St. Paul freeway network from all workdays of 1995-2019. Stations that repeatedly meet saturation conditions are chosen using fundamental diagrams (FDs) to determine the change in the throughput capacity of the entire network over 25 years. Network throughput drops from approximately 1850 veh/lane/hr in 1995 to approximately 1600 veh/lane/hr in 2019 and its standard deviation increases from approximately 110veh/lane/hr to approximately 190 veh/lane/hr. By connecting motor vehicles type and traffic levels at permanent classification stations, we determine the increase in the number of trucks is in part responsible for the decrease in throughput capacity.

Keywords: Network, throughput capacity, fundamental diagrams (FDs), trucks.

OPTIMIZATION OF RESELLING CANCELED ORDERS STRATEGY USING DEEP Q-NETWORKS WITH A CASE STUDY OF THE STEEL SLITTING INDUSTRY

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This paper addresses the optimal reassignment of canceled orders in the steel-slitting industry, introducing a novel solution method coined the Orienteering Problem with Pricing and Reselling Cancellation (OPPRC). The OPPRC problem is structured as a route-based Markov Decision Process, and we present a dual-method solution using Deep-Q Learning in tandem with an enhanced Genetic Algorithm. Using real-world case studies from a steel slitting firm, we explore the interaction between unit price, routing, and revenue. Our results demonstrate that the proposed method consistently outperforms existing benchmarks, achieving an advantageous balance between cost and revenue. The study underscores the necessity of simultaneous consideration of pricing and routing strategies for an effective reselling approach. Furthermore, our findings suggest that aggressive outreach to buyers during canceled order recalls may not always be necessary, with substantial profits potentially realizable at lower traveling costs.

Keywords: Markov decision process, route-based Markov decision process, Q-learning, reassignments, cancellations.

Abstract

RELIABLE LIFELONG PLANNING A*: TECHNIQUE FOR REOPTIMIZING RELIABLE SHORTEST PATHS IN DYNAMIC NETWORKS

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The reliable shortest path (RSP) problem that finds the optimal path between an origin and destination (O-D) has garnered significant attention due to its wide applications. With the fluctuation of travel demand, the link travel times may change over time. Consequently, the found path from the previous instance may no longer be optimal. One could simply utilize reliable shortest path algorithms to solve the new RSP problem independently from the previous instance. To address this change, this study proposes a reliable lifelong planning A*(RLPA*) technique for exactly solving the RSP problem on dynamic stochastic networks, where link travel time distributions update frequently. The proposed RLPA* technique is a reoptimization approach that enhances the path finding efficiency by reusing the path search results generated from the previous instance. Furthermore, the proposed RLPA* technique is further investigated to solve the K reliable shortest path (KRSP) problem, which is to find the K reliable shortest paths on stochastic networks. To verify the efficiency and effectiveness of the proposed RLPA* technique, a comprehensive case study using the real-world travel time distributions is carried out.

Keywords: Re-optimization technique, reliable path finding problem, travel time uncertainty, reliability, lifelong planning.

SESSION E4: PRICING AND REWARD

RESILIENT PRICNG: PROACTIVELY BUILDING UP NETWORK RESILIENCE VIA CONGESTION PRICING

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This study presents a novel congestion pricing scheme tailored for disruption-prone areas that considers the resilience of the network as a fundamental design element. With the new pricing scheme, the network can proactively build up such a network flow pattern which is both with adequate performance at the normal state and exhibits strong resilience after disturbance. A flexible two-stage bi-level stochastic programming model is established to formulate the problem to optimize the expected resilience while hedging against uncertain future disruptions. The post-disaster day-to-day route choice adjustment under toll is captured via an emerging Weibit-based day-to-day dynamic model. An efficiency deviation constraint is imposed to ensure that the pricing scheme does not lead to too much loss of network efficiency. The model can be further extended to incorporate the fairness constraint. Extensive numerical examples are provided to show the effectiveness of the proposed congestion pricing in enhancing network resilience. Managerial insights are also derived.

Keywords: Congestion pricing, resilience, travel demand management, optimization.

CREDIT CHARGE-CUM-REWARD SCHEME FOR GREEN MULTIMODAL MOBILITY

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To promote green mobility, we propose a credit charge-cum-reward (CCR) scheme where the government determines mode-specific credit charging/rewarding rates and redemption/charging prices. Over a CCR scheme period, travelers choose driving by consuming credits or taking transit to cumulate credits to minimize individual travel costs. In the end, the individual credit balance will be settled by the government at a charging (redemption) price for credit deficits (surpluses). We formulate the travelers' periodic mode usage equilibrium as a decision optimization problem. Based on the analysis of travelers' behavior, we further consider the impact of the government's credit-related budgets.

Keywords: Multi-modal mobility, credit charge-cum-reward scheme, periodic mode usage, congestion, emission.

Abstract

SPATIAL-TEMPORAL PRICING FOR COMPETITIVE RIDESOURCING PLATFORMS BASED ON MULTI-AGENT REINFORCEMENT LEARNING METHOD

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Shared autonomous vehicle (SAV) is rapidly expanding currently. The SAV platform will encounter fierce market competition during commercial operations. This paper innovatively adopts a multi-agent reinforcement learning method combined with a mesoscopic simulation model to solve the spatial-temporal pricing problem with competitive ridesharing (RS) platforms. A simulation that consists of two heterogeneous platforms (human-driven platform and SAV platform) is built up. The spatial price in each time slice is taken as strategies. The distribution of parking vehicles, cruising vehicles' destinations, and demand act as states for both platforms. A multi-agent RL algorithm named MADDPG is utilized to solve the problem. The results show that the model successively converges and generates the optimal spatial-temporal pricing strategy. The result demonstrates that the SAV platform achieves higher profit even with fewer vehicles and the spatial-temporal pricing outperforms dynamic and static pricing.

Keywords: Spatial-temporal pricing, multi-agent reinforcement learning, ride-sharing platform, autonomous vehicle, competitive market.

SESSION E5: TRANSPORT PLANNING AND SYSTEM DESIGN

OPTIMAL MIXED FLEET AND CHARGING INFRASTRUCTURE PLANNING TO ELECTRIFY DEMAND RESPONSIVE FEEDER SERVICES UNDER STOCHASTIC DEMAND

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The growing popularity of electrification in mobility services is driven by the need to reduce CO2 emissions. The performance of electric vehicle (EV)-operated services relies on the charging infrastructure configuration, which becomes challenging when addressing spatiotemporal demand variability in Mobility on-demand services (MODs) such as demand-responsive feeder services (DRFS). Real-world scenarios likely involve mixed fleets of EVs and gasoline vehicles (GVs), with electrification levels determined by CO2 reduction targets and investment costs. Although there is extensive literature on fleet management and charging infrastructure planning for fixed-route buses, fewer studies focus on the complex context of MODs. Existing research typically assumes fixed charging infrastructure and does not consider configurable CO2 reduction targets. To address these issues, this study presents a bi-level optimization problem that jointly considers fleet size, charging infrastructure, stochastic customer demand, CO2 emission reduction targets, charging station capacity constraints, and partial recharge. The upper-level problem optimizes the charging infrastructure configuration, while the lower problem formulates a mixed-integer linear programming problem to determine the mixed fleet size, composition, routing, and scheduling. A deterministic annealing algorithm is proposed for efficient problem-solving. Numerical experiments demonstrated that the proposed model effectively accounts for the influence of demand stochasticity on the effects that identical charging configurations can produce.

Keywords: Electric vehicle, demand responsive transport, fleet size optimization, charging infrastructure optimization, stochastic demand.

Abstract

ENHANCING TRANSPORTATION NETWORK RESILIENCE BY REDUNDANT DESIGN: A COMPACT MATHEMATICAL PROGRAMMING APPROACH

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Redundant design is widely accepted as a paradigm to enhance the resilience of complex systems. In transportation networks, redundant design is implemented by providing alternative routes for travelers, which provides rerouting opportunity for travelers during disruptions. To ensure the cost-effectiveness and applicability of redundant design, the underlying decision-making model should satisfy two requirements: (1) the new routes provided by redundant design is considered as alternative routes by travelers and possible to be used by them; and (2) the model can be solved efficiently in large-scale realistic networks. However, there is no existing model that can satisfy these two requirements. To fill the gap, this paper develops a new redundant network design problem (RNDP) which aims to construct behaviorally effective alternative routes provided to travelers and also is computationally solvable in large-scale networks. Specifically, the proposed RNDP maximizes the number of origin-destination pairs with multiple behaviorally effective routes under limited construction budget. As counting the number of effective routes does not have an equivalent mathematical programming formulation, we do not straightforwardly model the RNDP by its definition and formulate a bi-level programming without an explicit formulation. Instead, we find that the proposed RNDP can be casted as a maximal covering location problem, which has a single-level binary integer linear programming (BILP) formulation. We further prove that some greedy-based heuristic algorithms can find feasible solutions with upper-bounded optimal gaps, which assists the branch-and-bound algorithm to prune more efficiently. Case studies in the Winnipeg network are conducted to demonstrate the features of the model.

Keywords: Redundant design, resilience, maximal covering location problem, effective route.

A STUDY ON THE DESIGN OF A RESERVATION SYSTEM FOR URBAN TRANSPORT SERVICES UNDER UNCERTAINTY

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This study proposes a new reservation system that contributes to the efficiency of transport systems where recurrent and non-recurrent users share capacity-constrained transport services. We first present the outline of the proposed system, which we refer to as a bundled commuter pass scheme. We next describe a mathematical model of a transport system with the proposed scheme and construct a method of service reservation under the scheme by combining it with the auction theory. We then show that the proposed scheme maximises expected social surplus in the transport system, and has other desirable properties. In addition, we investigate the properties in more detail through numerical experiments with comparing to other schemes.

Keywords: Transport system management, reservation system, service bundling, resource allocation, uncertainty.

SESSION F1: RAIL TRANSPORTATION

RAILWAY RESILIENCE: PASSENGER-HOUR DELAYS UPON SERVICE DISRUPTIONS

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Railway resilience is an important topic in public transport management. While vast research has developed multiple system-based and topological metrics to measure resilience, there is still insufficient understanding in the impacts of railway disruptions upon passengers based on the historical disruption incidents. Also, the major causes of service delays and their associated impacts on passengers are not thoroughly examined. Hence, this study tries to address these research gaps by measuring the passenger-hour delays upon service disruptions of two railway transit operators between 2008 and 2018. A classification of major categories in service disruptions is proposed. Results indicate that passenger-hour delays can vary significantly across different railway lines and different types of service disruptions. In particular, the impacts of infrastructure issues and passenger/staff-related incidents can be as significant as severe weather events. Moreover, the distribution of passenger-hour delays in different types of disruptions can vary significantly by railway lines. In general, interchange stations are observed with higher passenger-hour delays. It suggests that, apart from the system-wide strategies to enhance railway resilience, more microscopic and context-specific measures can be formulated at the railway line and station levels. Future research can analyze the association of passenger-hour delays of each incident and the corresponding implemented measures so that more effective strategies of enhancing railway resilience can be formulated.

Keywords: Railway, resilience, passenger-hour delays, disruptions, public transport.

A BI-LEVEL DEEP REINFORCEMENT LEARNING FRAMEWORK FOR METRO TRAIN SCHEDULING AND SPEED CONTROL UNDER STOCHASTIC DISTURBANCES

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As cities grow in size and population, the need for efficient urban metro systems that are fast, high-capacity, and energy-saving is increasing. However, these systems face unpredictable disturbances during alighting, boarding and travelling. This paper introduces a bi-level model that uses deep reinforcement learning (DRL) to optimize train speed profile and operating timetable. The upper model optimizes the timetable by accounting for stochastic dwell times, ensuring energy efficiency and on-time arrival at the destination station. The optimized timetable is then passed down to the lower model as a reference. The lower model updates energy-saving driving regimes based on planned running time between station pairs provided by the upper model, overcoming deviations caused by unpredictable disturbances.

Keywords: Bi-level framework, deep reinforcement learning, metro train, stochastic disturbances.

Abstract

AN EMERGENCY DISPATCH MODEL FOR DOCKLESS SHARED BICYCLES IN RESPONSE TO METRO DISRUPTIONS

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Urban metros are the backbone of transport systems in large cities around the world. However, their superior capacity also contributes to the vulnerability of the transport system in response to metro disruptions, during which it is difficult to transfer the large number of stranded passengers via alternative modes. Most current studies are focused on bus bridging strategies, for which ensuring a quick response is difficult due to the bus parking location, road traffic, and weather conditions. Shared bicycles, which are a widely used emerging mobility service for last-mile metro connections, can be quickly dispatched to fill the gap of the current bus bridging strategies during metro disruptions. In this study, a mixed-integer programming model is proposed for shared bicycles dispatching in response to metro disruptions. The model is formulated as a fixed period multi-trip vehicle route problem (MTVRP). Moreover, a quadratic clustering method that combines set coverage with spatial clustering is developed to optimize shared bicycle nodes clustering. Then, the adaptive large neighborhood search (ALNS) is used to generate dispatching routes, and the variable neighborhood descent (VND) method is used to reinforce the dispatching solutions. Finally, the proposed model is verified with a case study of a metro disruption in Shanghai, China. The results show that, compared with the original algorithm, the proposed model can reduce the shared bicycle scheduling distance and trips of shared bicycles by 11.98% and 14.54%, respectively. The proposed method may be beneficial for enhancing the resilience of urban metro networks in response to disruptions.

Keywords: Metro disruption, dockless shared bicycles, emergency dispatch, quadratic clustering, vehicle routing problem.

SESSION F2: NETWORK RESILIENCE AND RECOVERY

ASSESSING RESILIENCE OF MULTI-MODAL TRANSIT NETWORKS: AN ACTIVITY-BASED ACCESSIBILITY ANALYSIS

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During the operation of multi-modal transit networks, disruption events may occur which result in significant socio-economic losses. These events not only reduce the supply capacity of transit networks but also affect individual activity and travel choice behaviours, further affecting the functionality of the transit network. However, there has been a lack of explicit investigation into the resilience assessment that precisely captures how individuals' daily activity-travel patterns vary in response to the degradation of multi-modal transit networks, especially with the use of an activity-based approach. In this paper, an activity-based accessibility metric is introduced for resilience measurement, which integrates travel choice behaviours, transit networks, and activity locations into a unified super-network framework. Additionally, multiple scenarios are designed to capture the factors that influence the network resilience based on the activity-based approach. Then, the performance of the proposed measure has been demonstrated on a multi-modal transit network in Xi'an, China. The measure enables decision-makers to accurately quantify the resilience and develop contingency plans by considering the created changes in travelers' activity and travel behaviours due to disruptions.

Keywords: Resilience, activity-based approach, accessibility, multi-modal transit network.

ALGORITHMS FOR OPTIMAL REPAIR SEQUENCING OF DAMAGED ROADS AFTER DISASTERS

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Natural disasters cause significant disruption in road networks, rendering many crucial links unusable. We study the problem of determining the optimal repair scheduling of damaged links so as to minimize the sum of the total system travel time over the repair duration given that multiple repair agencies are available for recovery. We consider a day-to-day traffic flow evolution where the route choices of travelers depend on the travel conditions of the previous day. We formulate this problem as a mixed integer non-linear program. We propose two solution methodologies – a genetic algorithm and a greedy algorithm. We test these methodologies and compare their performance. These algorithms provide efficient ways for timely repairing road networks after disasters while ensuring that the network performance is maximized.

Keywords: Disaster recovery, road networks, optimization, day-to-day dynamics, scheduling.

Abstract

DYNAMIC MOBILITY MANAGEMENT FOR HETEROGENEOUS POST-DISASTER POPULATION WITH HIDDEN MARKOV MODEL – A CASE STUDY IN SRI LANKA

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Currently residents' long-term migration after a disaster has been a timely concern in the world and it has become a primary topic among the researchers. Although there are many researches which describe the long-term residential behavior, consideration of psychological effects have not been implemented on model frameworks. In this study, Hidden Markov model (HMM) is considered for computing the belonging probabilities of hidden states and model outcome is incorporated in Discount recursive logit model (DRL) to study the behavior of the model after implementing latent characteristics. Maximum log likelihood method is used for the estimation and results can be used for a policy optimization problem in future studies.

Keywords: Hidden Markov model, recursive Logit model, dynamic heterogeneity, disaster recovery, EM algorithm.

SESSION F3: TRAFFIC PREDICTION

NETWORK-LEVEL TRAFFIC STATE ESTIMATION METHOD FOR MULTIPLE TIME PERIODS CONSIDERING THE MISSING TRAFFIC DATA

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This study proposed a method to estimate network-level traffic states of multiple time periods using the data observed from traffic counters and probe vehicles. The proposed method is applicable to the road network where the observation density of traffic data is not enough such as rural areas due to the low penetration rates of traffic counters and probe vehicles. The traffic states of link flows and link travel times are estimated by solving a full information maximum likelihood estimation problem which is constrained to the network equilibrium problem considering the stochastic demand, capacity and travel time. To solve this problem efficiently, the sensitivity algorithm to perturb the mean and coefficient of variation of traffic demand is proposed.

Keywords: Travel time reliability, stochastic traffic demand, traffic state estimation, data missing, probe data.

A POISSON-BASED DISTRIBUTION LEARNING FRAMEWORK FOR SHORT-TERM PREDICTION OF FOOD DELIVERY DEMAND RANGES

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With massive amounts of data on customers, drivers, and merchants, on-demand food delivery (OFD) platforms can achieve higher efficiency with better strategic and operational decisions. Some of these decisions, and especially proactive decisions in real time, rely on accurate and reliable short-term customer demand range predictions. In this paper, we develop a Poisson-based distribution prediction (PDP) framework to forecast the range and distribution of potential customer demand. Specifically, a bi-objective function is proposed to achieve two goals: minimizing the difference between the estimated and real distributions and minimizing the distance between the real demand and the predicted demand in the estimated distribution by argmax operation. Tailored backpropagation rules are also proposed to solve the PDP model. The proposed model, evaluated by numerical experiments based on a real-world dataset collected from an OFD platform in Singapore, outperforms several benchmarks by achieving more reliable demand range forecasting.

Keywords: Demand distribution prediction, label distribution learning, on-demand food delivery.

Abstract

MASTGAT: A MULTI-ATTRIBUTE SPATIAL-TEMPORAL GRAPH ATTENTION NETWORK FOR TRAFFIC PREDICTION

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Traffic forecasting is an indispensable issue in intelligent transportation systems (ITS), which has garnered widespread attention from academic and industry communities. Accurate traffic forecasting helps to improve the quality of traffic management systems and also contributes to the analysis of road network vulnerability. High-quality traffic forecasting can also reduce uncertainties in transportation systems. However, since the complicated correlations of traffic flow data and the limitation of monitoring equipment in urban road networks, traffic forecasting is a challenging task. In this paper, we propose a multi-attribute spatial-temporal graph attention network (MASTGAT) for traffic prediction, which combines with graph neural networks (GNN) and recurrent neural networks (RNN). Our model takes into account a variety of factors that affect the state of traffic flow such as road network topology, weather and POI. Specifically, MASTGAT constructs a multi-attribute graph to encode these factors. GNN and RNN are utilized to learn the spatial and temporal dependence of traffic data, respectively. Different from existing works, MASTGAT can model the dependencies between non-contiguous traffic nodes. Furthermore, our proposed model could take into account some traffic nodes without historical traffic data and forecast the traffic flow at these nodes.

Keywords: Intelligent transportation system, graph convolution network, traffic management, traffic speed forecasting, predict with missing data.

SESSION F4: CONNECTED VEHICLES AND TRAFFIC ASSIGNMENT

RESIDUAL VEHICLE EFFECTS ON VARIABILITY ESTIMATION OF CONNECTED VEHICLE PENETRATION RATE

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In the transition to complete connected vehicle (CV) deployment, the CV penetration rate is crucial to bridge the gap between partial and complete traffic information. Novel CV penetration rate estimation methods using only CV data have been proposed, but they are point estimators, and their direct application in modelling or system optimization may lead to biased estimations or suboptimal solutions. To address this, a probabilistic penetration rate (PPR) model has been proposed to estimate the uncertainty in the CV penetration rate. However, the model relies on a constrained queue length distribution constituted purely by queues formed during undersaturation conditions with no residual vehicles, which is not realistic. This paper proposes a Markov-constrained queue length (MCQL) model to account for residual vehicles and their complex effects on the CV penetration rate uncertainty. A constrained queue with residual vehicles is generically decomposed into four vehicle groups: observable constrained residual vehicles, unobservable constrained residual vehicles, unconstrained residual vehicles and new arrivals. While the first vehicle group is observable in the former cycle, the key challenge of this work is to model the residual vehicles from the second and third vehicle groups in combination with the new arrivals. Four sub-models are developed under the MCQL model to isolate and derive the distribution of the constrained vehicle set formed by the three latter vehicle groups, which is substituted into the PPR model for uncertainty estimation. Simulations show that the proposed MCQL model can accurately model the residual vehicle effect and estimate the uncertainty, enhancing the application potential of the PPR model in real-world situations.

Keywords: Connected vehicle, penetration rate uncertainty, probabilistic penetration rate model, residual vehicle, Markov-constrained queue length model.

Abstract

MODELING INSTANTANEOUS QUEUING EFFECT IN TRAFFIC ASSIGNMENT PROBLEMS UNDER DEMAND VARIATION

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This study investigated the effect of instantaneous queues on traffic assignment problems. An instantaneous traffic assignment model was proposed to consider within-period demand variations and was formulated it as a VI problem. An MSWA algorithm incorporated two fixed-point problems for network loading was developed to solve the proposed model. The performance of the proposed model was tested on a hypothetical network and a large-scale real-world study network in Hong Kong. It was found that instantaneous queues caused extra queuing delay and affected path choice, resulting in changes in link flows, path flows, and queues. Two main parameters are identified with significant impacts to the proposed model: the Coefficient of Variation of within-period demands and the number of instantaneous time intervals. The accuracy of the model's output was verified using real data collected from the study network in Hong Kong. This study provides insight into the impact of instantaneous queues on traffic assignment problems and can provide new avenue of research for developing more robust traffic assignment models to assess the network reliability and/or resilience under stochastic traffic conditions over short time intervals within the peak hour periods.

Keywords: Instantaneous queue, residual queue, demand variation, traffic assignment.

BOUNDEDLY RATIONAL CONTINUUM USER EQUILIBRIUM MODEL FOR SIMULTANEOUS DEPARTURE TIME AND ROUTE CHOICE IN TRAFFIC ASSIGNMENT PROBLEMS

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Based on Wardrop's first principle, the perfectly rational dynamic user equilibrium is widely used to study dynamic traffic assignment problems. However, due to people lack reliable information, or they are incapable of obtaining the optimized decision due to the complexity of the situations, the boundedly rational dynamic user equilibrium is more suitable to describe realistic travel behavior. In this study, we consider the simultaneous departure time and route choice problem incorporating the concept of bounded rationality. The continuum modeling approach is applied, in which the road network within the modeling region is assumed to be sufficiently dense and can be viewed as a continuum. We describe the traffic flow with the reactive dynamic continuum user equilibrium model and formulate the boundedly rational simultaneous departure time and route choice problem as a variational inequality problem. We prove the existence of the solution to our boundedly rational reactive dynamic continuum user equilibrium model under particular assumptions and provide an intuitive and graphical illustration to demonstrate the non-uniqueness of the solution. Numerical examples are conducted to demonstrate the characteristics of this model and the non-uniqueness of the solution.

Keywords: Dynamic continuum user equilibrium, bounded rationality, simultaneous departure time and route choice, existence, uniqueness.

SESSION F5: TRANSPORTATION NETWORK RELIABILITY II

HABITUAL PUBLIC TRANSPORT USE AS A SOURCE OF RELIABILITY

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Habitual travel or repeated travel routines can be a source of reliability for both transit users and transit planners as transit agencies can use past data to predict demand and allocate transit options in a more efficient manner. Habits are formed when behaviour is repeated frequently in a stable context and leads to rewarding outcomes, which is true for most everyday travel mode choices. Understanding habitual behaviour in the transit system can explain the factors influencing the selection of a routine and allow transit service providers to create the requisite opportunity. For example, if a particular journey is taken habitually, service providers can schedule more direct or frequent services during that time to minimize travel time, which is a reward for choosing this behaviour. This can contribute to providing more reliable services to habitual transit users and increasing habits in ridership there is positive feedback between these outcomes. Urban public transportation systems are critical to the economic and social functioning of cities, and the reliability and habituality of transit use are one aspect of efficient transportation policies and infrastructure. Transit smartcard data, which captures detailed information on users' travel behaviour, has emerged as a powerful tool for analysing the spatiotemporal habits of transit users. In this paper, we explore different temporal travel habits of transit users from transit smartcard data. smartcard data provides detailed information on users' travel patterns, including travel times, trip frequency, and trip purpose. This data is collected automatically when users tap their smartcards on transit systems, making it more accurate and reliable than traditional methods of travel data collection, such as surveys and roadside observations. Additionally, smartcard data is available in real-time, enabling policymakers to make data-driven decisions and respond to changing travel patterns. By analysing smartcard data, we can identify a taxonomy of habits, measure their prevalence and duration and quantify how habitual travel contributes to the reliability of the transit system. Overall, this study has the potential to contribute to a better understanding of urban transportation and inform policy decisions that improve the reliability of the public transport network.

Keywords: Public transport, reliability, habits and patterns, travel behavior, smartcard data.

OPTIMAL PUBLIC TRANSPORT FARE WITH DELAY INSURANCE TO IMPROVE TRAVEL TIME RELIABILITY

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The policy surrounding Public Transport (PT) fares is constantly evolving, particularly in light of discussions around Mobility as a Service. Strategies that incorporate mode integration and related fare structures can increase the appeal of PT by compensating for potential delays. This study suggests that premium fares with delay insurance could serve as a novel pricing tool to evaluate and enhance travel time reliability within a multimodal transportation network. The premium fare is set at a higher price point than the standard fare but provides passengers with the option to use an alternative service free of charge if the PT service is anticipated to be delayed beyond a specific qualification threshold. Passengers can choose between the two ticket types before their journey, and the operator strives to determine the most cost-effective price while minimizing the total social cost. Our model is applied to the Hankyu railway line network in Kyoto city, and our preliminary results indicate that implementing a proper premium fare could reduce travel costs but might also result in a decline in operator profit, necessitating subsidies.

Keywords: Travel time reliability, delay insurance, premium fares, multimodal network, public transport.

Abstract

ESTIMATION OF INDIVIDUAL-LEVEL PARAMETERS FOR A JOINT ROUTE AND DEPARTURE-TIME CHOICE MODEL CONSIDERING TRAVEL TIME RELIABILITY

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In this paper, following the theoretical underpinning of the integrated approach (Fosgerau and Karlström, 2010), individual-level parameters for a joint route and departure-time choice model with travel time reliability were estimated using Markov Chain Monte Carlo methods. Using a unique stated preference survey data, we explored individual-level scheduling preference parameters. The estimation results confirm the purpose of the trip affects the distribution of travelers' scheduling preferences, suggesting the need to discuss the importance of accounting for individual-level taste heterogeneity for travel time reliability in practices such as project appraisal.

Keywords: Travel time reliability, integrated approach, taste heterogeneity, Markov Chain Monte Carlo methods, urban expressway.

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