Special issue on Methodological Advancements in Understanding and Managing Urban Traffic Congestion

Zhong, Renxin; He, Zhengbing; Chow, Andy H.F.; Knoop, Victor

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Renxin Zhong, Zhengbing He, Andy H. F. Chow & Victor Knoop

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EDITORIAL

Special issue on methodological advancements in understanding and managing urban traffic congestion

The increasing population in cities induces a high travel demand. Unfortunately, due to the limited capacity of urban transport networks, this increasing demand for travel raises various problems and issues including congestion, energy, environmental impact, safety and security. Building new infrastructure is not a sustainable solution due to increasingly tight fiscal, physical and environmental constraints. A sustainable solution for mitigating urban congestion and other traffic-related problems calls for an understanding of urban traffic congestion characteristics and effective management of existing infrastructure through appropriate planning and control measures. Recent emerging technologies of connected and automated vehicles, vehicle-to-infrastructure, vehicle-to-everything environments and big data have made it easier and cheaper to collect, store, analyze, use, and disseminate multi-source data. Connected environments and vehicle automation technologies also make it more flexible for implementing real-time management and control measures for improving system performance. The scope for papers in this special issue explores the methodological and technological advancements in understanding and managing urban traffic congestion. The eight research papers which are included in this issue are summarized below.

The idea of treating roadway transport as a shared economy and managed by endowing right use to its users is becoming a reality with the advent of connected environments and vehicle automation technologies. Lessan and Fu (2022) explored the relevant body of literature by presenting an comprehensive review of the state-of-the-art methodologies on different variations of roadway-use right schemes, including credit- and permit-based mobility schemes with a specific focus on the three problems arising in these schemes – pricing, efficient allocation and charging of permits or credits for mobility management over the past two decades. This survey provides an improved understanding of the fundamental constructs of these problems by systematically classifying the problem variants, proposed methodologies, and modelling attributes. The research gaps and challenges such as the mobility right endowment, pricing/charging problems, implementation issue are discussed, while some possible perspectives and directions for future research are suggested.

Wang et al. (2022) proposed a nonnegative tensor decomposition framework for the mobile phone data to reveal the spatial–temporal patterns of urban mobility. Massive trips among cellular base stations were extracted from the mobile phone signaling data. The human mobility data with the information such as timestamp, trip origin and destination were formulated to a threeway tensor. The nonnegative tensor decomposition model with nonnegative matrix factorization (NMF) initialization was introduced to decompose the trips tensor into a core tensor and multiple factor matrices to extract hidden spatial and temporal structures of multi-dimensional trips data. The performance of the proposed method was evaluated by using the data of millions of trips in one week collected from over 4 million cell phone users in Hangzhou, China.

Luan et al. (2022) used the travel time volatility (TTV) to quantify travel time uncertainties. Both link and path-level TTV distribution were derived. The path-level TTV distribution analysis constructed by using the copula-based method provides travelers with understandable and interesting information, such as short-term path travel time estimations and probabilistic negative or positive extreme cases at various confidence levels. Three empirical studies in Beijing with varying numbers of links were conducted to demonstrate the effectiveness of the proposed method. Compared with convolution-based models, the results of the proposed method are more accurate and convergent in extreme cases, thereby significantly benefiting risk-averse travelers. Furthermore, the results are more convergent and accurate than those from the empirical- and normal-based methods.

Li et al. (2022) proposed a hybrid deep learning model to address two of the main difficulties in traffic incident detection, i.e. the small sample sizes and imbalanced datasets. In the proposed model, a generative adversarial network (GAN) was used to expand the sample size and balance the samples. A temporal and spatially stacked autoencoder is used to extract the temporal and spatial correlations of the traffic flow and detect incidents. The model was tested using a real-world dataset, and the results showed that the proposed model can accurately detect traffic incidents and outperforms some benchmark models due to the consideration of both temporal and spatial variables.

Zhang et al. (2022) proposed a heterogeneous variable message signs (VMS) location problem based on a stochastic model of accidents in a freeway network. The problem was formulated as a two-stage stochastic programming model. Both gantry and cantilever mounted VMS that displays passive and active real-time messages were considered. The location and type of VMS installation were considered in the first-stage model. The performance of VMS location solutions was evaluated in the second stage as a mixed-integer linear programming problem via minimizing the total travel time and the penalty for misleading guidance. The Nguyen-Dupuis and Sioux-Fall networks were used to verify the effectiveness of the proposed models.

Bai et al. (2022) proposed a cooperative weaving for connected and automated vehicles to reduce traffic oscillations induced by the lane-changing maneuvers at weaving areas. The motion planner developed in this paper only requires longitudinally automation, which is accessible for most commercialized luxury vehicles. Simulations were conducted to quantify the performance of the proposed motion planner. It was found that the cooperative weaving motion planner was effective in reducing traffic oscillations.

Yu and Hou (2022) proposed a two-level hierarchical optimization control method for an urban traffic network. At the upper level, a data-driven model-free adaptive control method was used to optimize the set-point for the number of vehicles on each link. At the lower level, traffic signals were regulated with the model predictive control with the desired reference signals obtained from the upper level. Through this scheme, the planning of vehicle distribution in a road network and traffic signal control operation can be executed simultaneously.

Zhou et al. (2022) proposed a systematic fare incentive strategy to manage peak-hour congestion in urban rail transit (URT) systems based on the theory of time and route peak spreading. Various attributes that influence the departure time and route choices of passengers were investigated. Passengers' willingness to change their departure time or routes was evaluated based on a questionnaire survey of passengers of Shanghai metro. The interrelationships between fare incentives and the choice behavior of passengers were identified using the discrete choice model. Two fare incentive strategies that consider the changes in time or space, namely, a time-based fare incentive strategy and a route-based fare incentive strategy, were proposed. Their effectiveness was evaluated using the Shanghai URT network simulation.

In conclusion, the eight papers included in this special issue provide comprehensive coverage of methodological and technological advancements in understanding and managing urban traffic congestion. The guest editors would like to express their sincere gratitude to the editor-in-chief of the journal for providing an opportunity for this special issue to be published. The guest editors would like to thank all authors and reviewers for their highly appreciated contribution to this special issue.

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No potential conflict of interest was reported by the author(s).

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Renxin Zhong
School of Intelligent Systems Engineering,
Sun Yat-sen University,
Guangzhou, People's Republic of China
zhrenxin@mail.sysu.edu.cn
http://orcid.org/0000-0003-1559-7287
Zhengbing He
College of Metropolitan Transportation, Beijing University of Technology,
Beijing, People's Republic of China
http://orcid.0000-0001-5716-3853

Andy H. F. Chow
Department of Architecture and Civil Engineering, City University of Hong Kong, Hong Kong, People's Republic of China
http://orcid.0000-0002-2877-357X
Victor Knoop
Department of Transport & Planning, Delft University of Technology, Delft, The Netherlands
http://orcid.0000-0001-7423-3841