Received: 30 October 2022 | Accepted: 8 February 2024

DOI: 10.1049/itr2.12496

IET Intelligent Transport Systems

The Institution of Engineering and Technology WILEY

GUEST EDITORIAL

Guest Editorial: Modelling, operation and management of traffic mixed with connected and automated vehicles

1 | INTRODUCTION

Connected and automated vehicle (CAV) technology has undergone significant development in the last decades. The traffic mixed with vehicles of various automation and communication levels will become the main body of the future transportation system, which makes the traditional theories of transportation research face great challenges. Such ongoing and forthcoming challenges make traffic mixed with CAVs a priority for research with interests across the spectrum of governmental agencies and industries.

Although a number of studies have been dedicated to the driving behaviours of vehicles with different intelligence and networking technologies, the following questions regarding mixed traffic are still open: (1) How do various types of vehicles operate in the heterogeneous traffic flow? (2) How do they interact with each other? (3) What is the evolution mechanism of the mixed traffic? (4) How to improve the efficiency of mixed traffic by optimizing vehicle trajectory and providing reasonable coordinated traffic control methods? The current special issue is focused on research ideas, articles and experimental studies related to modelling, operation and management of traffic mixed with CAVs, regular vehicles (RVs), automated vehicles (AVs) and connected vehicles (CVs).

2 | PAPERS IN THE SPECIAL ISSUE

In this special issue, we have received eight papers, all of which underwent peer review. Mixed traffic is investigated from three perspectives, namely, driving behaviours modelling, driving behaviours optimization, and traffic flow modelling. The papers laying in the first category exhibit novelties in driving behaviours analysis and simulation. The papers in this category are by Jami et al. and Yao et al. The second category of papers offers solutions to driving behaviour optimization by means of coordinate induction and traffic control. These papers are by Wang et al. and Huang et al. The last category proposes new methods concerning traffic state identification and traffic flow prediction. These papers are by Qi et al., Yang et al., Qi et al. and Guo et al. A brief presentation of each of the papers in this special issue follows.

Jami et al. [1] present a simulation platform for a hybrid transportation system that includes both human-driven and automated vehicles. They decompose the human driving task and offer a modular approach to simulate a large-scale traffic scenario, allowing for a thorough investigation of automated and active safety systems. A large driving dataset is analysed to extract expressive parameters that would best describe different driving characteristics. Then a similarly dense traffic scenario within the simulator is recreated, and a thorough analysis of various human-specific and system-specific factors is conducted by examining their effects on traffic network performance and safety.

Yao et al. [2] propose a fully sampled trajectory reconstruction method for traffic mixed with RVs, CVs and CAVs. Considering the minimum safety distance constraints between vehicles, they develop an optimization model for minimizing the impact on the acceleration of the known vehicles in order to obtain the number of inserted RVs. The speeds of the inserted RVs are then estimated, and an optimization model is proposed to determine the position of each of the inserted RVs. The influence of traffic density and the penetration rates of CAVs and CVs are considered in the numerical simulation. The simulation results show that the proposed methods better reconstruct the vehicle trajectory on the freeway under different traffic densities in a congested state.

Wang et al. [3] construct a model to examine the effects of three lane management strategies concerning CAV priority under mixed traffic. The best strategy for different CAV penetration rates and traffic demands is recommended, respectively according to the evaluation results. The simulation results indicate that the proposed lane management strategies are conducive to improving driving speed and reducing the variance of speed distribution and driving delay.

Huang et al. [4] develop a universal approach to model fuel consumption under mixed scenarios involving different combinations of RVs and CAVs. From a platoon perspective, the driving stability of CAVs and vehicle-specific power distribution are employed to quantify fuel consumption. Then a library of fuel consumption profiles is established for multiple penetration rates, platoon intensities, and speeds. The results reveal a decrease in fuel consumption with the increase in CAV penetration rates and speed of the platoon.

Qi et al. [5] propose a method to detect, avoid, and recover from deadlock for AVs mixed with HDVs in an unstructured environment. Two detection algorithms based on evasion

distance propagation are proposed for weak and strong deadlocks, respectively. And a cooperative control method is presented to avoid deadlock based on chain-spillover-free and loop-free strategies. Moreover, in the event that a deadlock has already happened, cooperative protocols based on re-routing and backward-forward strategies are designed to recover traffic flow from deadlock. With a test in Carla, the proposed methods were proven to successfully detect the deadlocks 13 s earlier than their occurrence and unlock the existing deadlock in about 6 s. In addition, by implementing the quick detection and recovery method, traffic throughput increased by 35.7% and 18%, respectively.

Yang et al. [6] explore the relationship between traffic flow states and crash type/severity in the scenarios of normal crashes, primary crashes, and secondary crashes using the association rules mining approach. Based on the crash data and real-time traffic data collected from the I-880 freeway for five years in California, United States, they successfully identified the secondary crashes and traffic flow states by using a speed contour plot approach and the three-phase flow theory, respectively. The contributions have the potential to reduce the secondary crash probability.

Qi et al. [7] apply a hybrid deep learning model based on multi feature fusion to predict traffic flow by considering weather conditions. A comparison with other representative models validates that the proposed fusion spatial-temporal graph convolutional network achieves better performance.

Based on electronic toll collection (ETC) transaction data and global positioning system (GPS) data, Guo et al. [8] propose an ETC gantry positioning method. Combined with dead reckoning (DR) and median centre, the potential position of the gantry is calculated from ETC transaction data and GPS data. Then the switching strategy based on the Kalman filter (KF) is used to capture the final gantry position. By comparing the results of the proposal with the collected gantry position, it is found that the positioning error of the gantry position calculated by this proposal is about 37 m, and the developed model helps to effectively locate expressway gantries with a positioning accuracy of 98.78% with a threshold of 100 m.

3 | SUMMARY

All of the papers selected for this special issue show that the field of modelling, operation and management of traffic mixed with CAVs is steadily moving forward. Nevertheless, from the perspective of future technological development, there remains a source of inspiration for innovation research in the years to come, mainly reflected in three aspects: (1) the dynamic coupling relationship between the cyber and physical network of the transportation system in an intelligent network environment; (2) the driving characteristics of RVs in mixed traffic; and (3) traffic prediction and control at the trip chain level from a macro perspective.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to all the contributors who submitted novel scientific results in this special issue and to the anonymous reviewers, whose expert work allowed the realisation of this endeavour. The authors aspire that this effort should contribute to the further development of mixed traffic and increase the concern of the scientific and technological communities in the respective areas. Moreover, the authors express their appreciation to the journal's Editors-in-Chief and the Editorial Office for their support throughout this venture.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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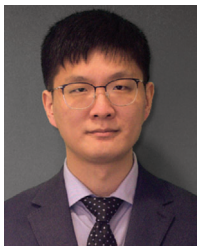
Fang Zong received the B.S., M.S., and Ph.D. degrees in transportation planning and management from Jilin University, Changchun, China, in 2002, 2005, and 2008, respectively. She is currently a professor at the College of Transportation, Jilin University, China. She has totally completed over 50 research projects and obtained seven national invention patents. Her research interests include travel behaviour analysis, travel behaviour identification with GPS data, decision-making, and intelligent optimization. She has published over 40 journal and conference proceedings papers in the above research areas, including IEEE Transactions on Intelligent Transportation Systems and Transportation Research Part D, and so on. She is on the editorial board of Biostatistics Research, the Journal of Transportation Engineering and Information, the Journal of Southwest Jiaotong University and Journal of Transport Information and Safety. She also serves as a frequent reviewer for over 30 international journals.

Renxin Zhong is currently an associate professor with the School of Intelligent Systems Engineering at Sun Yat-sen University. He is the Deputy Director of the Guangdong Key Laboratory of Intelligent Transportation Systems. His main research interests include traffic incident detection and management strategies, machine learning and data mining for transportation big data analysis, and optimal and non-linear control theory with applications in transportation engineering. He received the Outstanding Dissertation Paper Award and the Gordon Newell Memorial Prize at the 17th HKSTS International Conference, as well as the First Runner-up of the HKSTS Outstanding Student Paper Award at the 14th HKSTS International Conference. His article was shortlisted for the Best Paper Award at the IEEE ITSC 2018. His team won third place in KDD Cup 2017 (freeway travel time and traffic flow estimations), KDD Cup 2018 (urban pollutant prediction), and second place in KDD Cup 2020 (reinforcement learning). He serves as an associate editor for Transportmetrica A and Transportmetrica B and a guest editor for several journals.



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