Received: 28 March 2022 | Accepted: 14 September 2022

DOI: 10.1049/itr2.12282

IET Intelligent Transport Systems

The Institution of Engineering and Technology WILEY

GUEST EDITORIAL

Guest editorial: Decision making and control for connected and automated vehicles

1 | INTRODUCTION

As a transformative technology, connected and automated driving technology is expected to deal with the issues of traffic congestion and conflicts, and meanwhile to ensure the driving safety in intelligent transportation systems (ITS). In a connected driving environment, the motion states, surrounding traffic situations, and even the intentions and planned behaviours of driving can be shared between connected automated vehicles (CAVs). This enables the correct, reasonable, and effective decisions to be made for multi-vehicle interactions, particularly in complex situations.

Moreover, the collaborative control between vehicles can be realised. As a result, the driving safety, travel efficiency, riding comfort, and fuel economy can be improved. Though many researchers have made continuous efforts in the field of decision making and control for CAVs, some issues urgently need addressing, for example, robustness and generalisation of algorithm, computational efficiency of algorithm, algorithm security to deal with cyber-attack scenarios within networked control environments, etc.

The objective of this special issue is to propose a systematic framework for decision making and control of CAVs. Recent advances in both theory and applications related to this research topic are discussed.

2 | PAPERS IN THE SPECIAL ISSUE

This special issue contains 10 papers covering topics of trajectory prediction, decision-making, and trajectory planning algorithms for CAVs, cyber security, platooning control of CAVs, vehicle safety and stability control, as well as unmanned aerial vehicle control.

Li et al. proposed a deep reinforcement learning method to address the continuous decision-making problem for autonomous vehicles at intersections. The proposed method established an end-to-end decision-making framework by using the convolutional neural network to map the relationship between traffic images and vehicle operations. The interaction between the AV and other vehicles was modelled as a Markov Decision Process (MDP), and the deep deterministic policy gradient algorithm was employed to solve the MDP problem and obtain the optimal driving policy. The experimental results demonstrated that the developed method could provide effective policies to ensure driving safety and efficiency while considering driving comfort for autonomous driving at intersections.

Chen et al. proposed a mixed Conditional AutoEncoder Generative Adversarial Network model to address the vehicle trajectory prediction problem. The proposed model used the encoder–decoder structure with a convolutional social pool to extract general features. The generative adversarial networks were used to extract the confidence features of the generated trajectories. In addition, a classifier structure was added based on an LSTM network to output the probability, such that the generated trajectory lateral manoeuvre of the model was consistent with the ground truth. The proposed model was evaluated using the real-world NGSIM US-101 and I-80 datasets, and results showed that the accuracy of the proposed model was higher than that of the existing methods.

Cai et al. designed a Platoon Sharing Deep Deterministic Policy Gradient Algorithm for a multi-vehicle network. The proposed approach overcomes the problem of low efficiency of continuous action space exploration. Additional platoon noises were added to enhance the diversity of training samples during exploration, improving model robustness. Time sequence information and replay buffer backup were leveraged to prevent insufficient explorations. The robustness of the proposed algorithm was verified in simulation under scenarios of platoon merging, overtaking, cruising following, and obstacle avoidance. The simulation results showed that the proposed algorithm has a great potential to reduce energy consumption and improve road efficiency for platoons.

Lyu et al. proposed a communication topology safety response system (CTSRS), which is further combined with a distributed model predictive control (DMPC) method, to improve the longitudinal control performance for connected and automated truck platoon (CATP). The sufficient conditions for the asymptotic stability of the truck platoon were derived by taking the cost function of CATP as the Lyapunov candidate function. The superior control performance was verified using real-world driving data under different driving behaviours. Further, a cyberattacks scenario was set to conduct the comparative numerical simulation of platoon evolution, and the results showed that together with CTSRS, the DMPC can still ensure the stability and security of the truck platoon under cyberattacks, demonstrating the feasibility and the performance improvement of the proposed method.

Chen et al. presented a finite time disturbance observer (FTDO)-based super-twisting sliding mode control (SMC) for a vehicle platoon system against parameter uncertainties and external disturbances. To compensate uncertainties and disturbances, a composite FTDO-based super twisting SMC method was developed under zero initial spacing deviations. Besides, an improved time gap policy was employed to extend the developed control scheme to a more general case with non-zero initial spacing deviations. The individual stability of each vehicle was rigorously analysed by using the Lyapunov stability theory. Further, the strong string stability of the whole vehicle platoon was derived with the help of the Laplace transform. Finally, numerical simulations were conducted to illustrate the effectiveness and implementation ability of the developed control scheme.

Dalwadi et al. designed a backstepping controller and an adaptive backstepping controller for trajectory tracking and payload delivery of unmanned aerial vehicles (UAVs) in a medical emergency condition with wind gust. Simulation results showed that the backstepping controller can effectively track the trajectory during the entire flight envelope, including take-off, hovering, the transition phase, level flight mode, and landing. A comparison between backstepping, integral terminal sliding mode (ITSMC), and adaptive backstepping controllers for payload delivery showed that the adaptive backstepping controller effectively tracked the altitude and attitude.

Di et al. proposed an active safety and stability controller for independent-driven electric vehicles towards recovering the vehicle to safety states after an impact. The controller aims to regulate the course angle and lateral deviation that enforce the vehicle back to its original driving path. The upper-level controller is derived based on the sliding mode technique. And the low-level controller aims to solve a convex quadratic allocation problem, which inherently incorporates fault-tolerance property. The feasibility and effectiveness of the proposed controller were validated in both urban and highway accident conditions in simulation.

S. Li et al. proposed an integrated optimisation model for on-ramp automated vehicles, which is capable of guiding the vehicle to complete the merging behaviour from the ramp lane to the main lane safely and efficiently. A two-dimensional spatial-temporal trajectory is determined to guide on-ramp automated vehicles to decide where, when, and how to merge into the mainline traffic flow. The numerical results validate the effectiveness of the proposed model through the microscopic and macroscopic numerical results under different levels of mixed traffic.

P. Huang et al. presented an event-triggered overtaking decision-making strategy for autonomous vehicles to make the overtaking meet the driver's expectations. Difference between the left-lane change and the right-lane change is analysed first. Then considering surrounding vehicles' changes in both speed and acceleration, an optimisation of overtaking decision-making strategy is proposed. Simulation results show that the proposed overtaking decision-making strategy, which can reflect driver habits and preferences, performs well and avoids frequent lane changes.

D. Xiao et al. investigated mainline variable speed limit (VSL) adjustment of off-ramp upstream is with the reinforcement learning algorithm under the connected vehicles environment to alleviate the traffic congestion. Three control schemes, including free control, mainline VSL adjustment of off-ramp upstream based on feedback, and mainline VSL adjustment of off-ramp upstream based on Q-learning algorithm, are designed, and the three schemes are simulated and compared quantitatively to reflect the off-ramp travel efficiency. The results indicate that mainline dynamic VSL adjustment of off-ramp upstream performs the best in terms of general and specific indexes, showing great potential for reducing congestion and improving traffic flow control for CAVs.

3 | SUMMARY

All the selected papers in this Special Issue contain interesting new findings on decision making and control for multi-modal connected and automated vehicles. They demonstrate novel system design, software algorithms, and automation solutions. Besides, these papers present solid validation results using real-world data or experimental testing. This Special Issue shows that the joint efforts across multi-disciplinary domains have a great potential to address the challenges of CAVs and future mobilities.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analysed in this study.

GUEST EDITOR BIOGRAPHIES

Chen Lv, Nanyang Technological University, Singapore is a Nanyang Assistant Professor at School of Mechanical and Aerospace Engineering, and the Cluster Director in Future Mobility Solutions, Nanyang Technological University, Singapore. He received his PhD degree at Department of Automotive Engineering, Tsinghua University, China in Jan 2016. He was a joint PhD researcher at UC Berkeley, USA during 2014–2015, and worked as a Research Fellow at Cranfield University, UK during 2016–2018. He joined NTU and founded the Automated Driving and Human-Machine System (AutoMan) Research Lab since June 2018. His research focuses on intelligent vehicles, automated driving, and human–machine systems, where he has contributed 2 books, over 100 papers, and obtained 12 granted patents. He serves as an Associate Editor for IEEE T-ITS, IEEE TVT, and IEEE T-IV. He received many awards and honors, selectively including IEEE IV Best Workshop/Special Session Paper Award in 2018, Automotive Innovation Best Paper Award in 2020, the winner of Waymo Open Dataset Challenges at CVPR 2021, and Machines Young Investigator Award in 2022.

Peng Hang is currently a Research Fellow with the School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore. His research interests include decision making, motion planning, and control for connected automated vehicles. He received the Ph.D. degree with the School of Automotive Studies, Tongji University, in 2019. He has been a Visiting Researcher with the Department of Electrical and Computer Engineering, National University of Singapore, and a Software Engineer in Research & Advanced Technology Dept., SAIC Motor, China. He received many awards and honours, including Excellent Doctoral Thesis of Tongji University, APAC Excellent Paper Award, etc. He serves as the Topic Editor or Guest Editor for Games, Vehicles, Autonomous Intelligent Systems, and Actuators.

Yang Xing is a Lecturer in Applied Artificial Intelligence, Cranfield University, UK. He received his Ph.D. degree from Cranfield University in July 2018. Before joining Cranfield University in 2021, Yang worked as a research associate with the University of Oxford from 2020 to 2021, and a research fellow with Nanyang Technological University from 2019 to 2020. His research interests focus on artificial intelligence, deep learning, computer vision, human-autonomy collaboration, and autonomous vehicles, where he has contributed 2 books and over 50 papers (including 2 ESI highly cited papers) on high-quality peer-review journals and conferences. Dr. Yang Xing serves as an Associate Editor in IEEE Transactions on Intelligent Vehicles, and Review Editor in Frontiers in Mechanical Engineering. He was a Guest Editor-in-Chief/Editor in IEEE Internet of Things Journal, Frontiers in Mechanical Engineering, and IEEE Intelligent Transportation Magazine, etc. He won the Best Workshop/Special Session Paper on IEEE IV 2018 and Best Paper on China National Intelligence Technology Conference 2019.

Anh-Tu Nguyen is an Associate Professor at Université Polytechnique des Hauts-de-France, France. Dr. Nguyen received the Engineering degree (French Diplôme d'Ingénieur) and the Master degree in Automatic Control in 2009 from Grenoble Institute of Technology, France. After working a short period in 2010 at the French Institute of Petroleum (IFP Énergies Nouvelles, Paris), he began his doctoral program at the laboratory LAMIH UMR CNRS 8201, in close collaboration with Valeo Group. He got his PhD degree in Automatic Control in 2013 from the University of Valenciennes, France. From February 2014 to August 2018, he was a postdoctoral researcher at the CNRS laboratories LAMIH UMR 8201, Valenciennes, France and LS2N UMR 6004, Nantes, France. Since September 2018, he has been an Associate Professor at the Université Polytechnique des Hauts-de-France and a researcher at the LAMIH laboratory, Valenciennes, France. He is an Associate Editor for the IEEE Transactions on Intelligent Transportation Systems, the IET Journal of Engineering, the Springer journal Automotive Innovation, and an Early Career Advisory Board member of the IFAC journal Control Engineering Practice. Dr. Nguyen's research interests include robust control and estimation, human–machine shared control with a strong emphasis on mechatronics applications.

Alireza Jolfaei is an Associate Professor of Cyber Security and Networking in the College of Science and Engineering at Flinders University, Adelaide, Australia. Prior to this, he has been a faculty member with Macquarie University, Federation University, and Temple University in Philadelphia, PA, USA. His research is centred around Cyber and Cyber-Physical Systems Security. On these topics, he published over 100 papers, which appeared in peer-reviewed journals, conference proceedings, and books. He completed his PhD in Applied Cryptography at Griffith University and received a prestigious IEEE Australian council award for his PhD research paper published in the IEEE Transactions on Information Forensics and Security. He served as the guest associate editor of IEEE journals and transactions, including the IEEE IoT Journal, IEEE Sensors Journal, IEEE Transactions on Intelligent Transportation Systems, and IEEE Transactions on Industry Applications. He has served as a program Co-Chair, a track Chair, a session Chair, and a Technical Program

Committee member, for major conferences, including IEEE TrustCom and IEEE ICCCN.

Chen Lv[1]
Peng Hang[2]
Yang Xing[3]
Anh-Tu Nguyen[4]
Alireza Jolfaei[5]

[1] *Nanyang Technological University, Singapore*
[2] *Tongji University, Shanghai, China*
[3] *Cranfield University, Cranfield, UK*
[4] *Université Polytechnique des Hauts-de-France, Valenciennes, France*
[5] *Flinders University, Adelaide, Australia*

Correspondence
Chen Lv, Nanyang Technological University, Singapore
Email: lyuchen@ntu.edu.sg

ORCID
Chen Lv https://orcid.org/0000-0001-6897-4512

2022-10-17

Guest editorial: Decision making and control for connected and automated vehicles

Lv, Chen

Institution of Engineering and Technology (IET)

Lv C, Hang P, Xing Y, et al., (2022) Guest editorial: Decision making and control for connected and automated vehicles. IET Intelligent Transport Systems, Volume 16, Issue 12, Special Issue: Decision making and control for connected and automated vehicles, December 2022, pp. 1665-1668

https://doi.org/10.1049/itr2.12282