Editorial
Special Issue on AI Innovations in Intelligent Transportation Systems

REGARDLESS of whether we are living in smart cities or not smart cities, the technologies involved in organizing and planning for smart transportation systems are already in use including smart sensors, controlled actuators, and other sensing and action devices along with massive information collected on logistics, routing, vehicles, passengers, mapping, and planning. The use of these technologies and many other associative technologies including smart connected vehicles and traffic forecasting systems are contributing to the development of a sustainable transport system that can have minimal incidents. However, these technologies did not solve most of the traffic congestions nor be able to use a mobility single interface to plan trips as well as to integrate more smart algorithms for efficient traffic management.

AI methods that are proven to be effective in other fields like cyber-physical systems can provide immense support for solving most of the challenges of the transportation systems. Many innovations and predictions are now possible with the use of a variety of embedded models including those that are generated from neural networks (ANNs), genetic algorithms (GA), fuzzy logic model (FLM) and ant colony optimizer (ACO), and other AI branches like reinforcement learning, neuro-symbolic AI, VQA, Thick and Big Data Analytics, as well as from the field of Smart IoT.

The accepted articles in this Special Issue introduce flora of AI techniques that can be employed by the legacy transportation management systems to enable them to work more effectively. The issue has accepted 34 articles. In the following, we are summarizing each of these accepted articles.

In [A1], Zhou *et al.* proposed a real-time prediction model of situation awareness in conditionally automated driving, using both LightGBM (Light Gradient Boosting Machine) and SHAP (SHapley Additive exPlanations). The model that only takes eye-tracking measures has good performance when situation awareness is aggregated using three performance measures (i.e., vehicle placement, distance, and speed estimation). The model also identifies the main effects of the selected predictor variables. Such domain knowledge about situation awareness can potentially help design human–machine systems to optimize joint performance in conditionally automated driving.

In [A2], Li *et al.* proposed a real-time tracking algorithm using improved convolutional neural networks (CNNs) and transfer learning to address the poor image feature extraction ability, excessive tracking time, and low accuracy of traditional real-time algorithms for aerial tracking of vehicle traffic. This article designs a deep convolution feature extraction structure to extract the depth features of the images. The target vehicle motion model is established, the similarity between the target and candidate models is calculated, and the real-time tracking of aerial vehicles is completed.

In [A3], Li *et al.* leverage a novel neural network-integrated with a heterogeneous attention mechanism to empower the policy in deep reinforcement learning to automatically select the nodes to address the challenging issue in handling well the pairing and precedence relationships in the pickup and delivery problem (PDP), which is a representative variant of VRP.

In [A4], Sutrala *et al.* proposed a new three-factor user authentication and key agreement scheme (UAKA-5GSICPS) for 5G-enabled SDN-based ICPS environment. UAKA-5GSICPS allows an authorized user to access the real-time data directly from some designated Internet of Things (IoT)-based smart devices, provided a successful mutual authentication among them is executed via their controller node in the SDN network. It is shown to be robust against various potential attacks through detailed security analysis including the simulation-based formal security verification.

In [A5], Zhang *et al.* use pose estimation (keypoint detection) to generate pedestrians' variables from CCTV videos. Four machine learning models are used to predict pedestrians' crossing intention at intersections' red-light. The best model achieves an accuracy of 0.920 and an AUC value of 0.849, with data from three intersections. Different prediction horizons (up to 4 s) are used. With longer prediction horizons, the sample size gets smaller, which partially leads to worse model performance. However, the performance with the prediction horizon up to 2 s is still good (AUC value as 0.841). This model can be further implemented in the Infrastructure-to-Vehicle (I2V) application and used for issuing pre-warnings to drivers.

In [A6], Lin *et al.* developed a high accident risk prediction model to analyze traffic accident data and identify priority intersections for improvement. Using Bayes' theorem to identify environmental variables at intersections that affect accident risk levels, this study found that road width, speed limit, and roadside markings are the significant risk factors for traffic accidents. Meanwhile, Naïve Bayes, decision tree C4.5,

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Bayesian network, multilayerperceptron (MLP), deep neural networks (DNNs), deep belief networks (DBNs), and convolutional neural network (CNNs) were used to develop an accident risk prediction model. This model can also identify the key factors that affect the occurrence of high-risk intersections, and provide traffic management departments with a better basis for decision-making for intersection improvement.

In [A7], Zhang *et al.* conducted a task in a two-step strategy: candidate frame selection and loop closure verification. The first step aims to search semantically similar images for query one using features obtained by Key.Net with HardNet. Instead of adopting the traditional Bag-of-Words strategy, the authors utilize the aggregated selective match kernel to calculate the similarity between images. Subsequently, based on the potential property of the motion field in the LCD scene, they propose a novel feature matching method, i.e., exploiting the smoothness prior and learning the motion field for an image pair in a reproducing kernel Hilbert space, to implement loop closure verification.

In [A8], Derhab *et al.* propose H-IDFS, a novel intrusion detection and filtering framework for in-vehicle networks. H-IDFS uses a histogram representation of CAN traffic windows and classifies them as normal or malicious. If the window is found malicious, it filters out the normal CAN packets from each malicious window using a novel one-class SVM.

In [A9], Zhu *et al.* propose a semi-supervised federated learning (SSFL) framework that can accurately identify travel modes without using users' raw trajectories data or relying on notable data labels. Specifically, the authors propose a new identification model named the convolutional neural network-gated recurrent unit model in SSFL to accurately infer travel modes from GPS trajectories. Second, they design a pseudo-labeling method for the clients to set pseudo-labels on their local unlabeled dataset by using a small public dataset at the server. Furthermore, the authors adopt a grouping-based aggregation scheme and a data flipping augmentation scheme, which can boost the convergence and performance of the proposed framework.

In [A10], Wen *et al.* exploit a deep-learning technology to model the wireless propagation, which was very difficult to deterministically predict at a fast speed in our previous research due to the high computation demand. In this proposed wireless propagation model, the Kalman filter is utilized to update the neural network parameters online, which makes this model can meet the variation of the environment. The numeric evaluation result shows that the deep neural network-based wireless channel model can precisely predict the outage probability with a very low computational cost.

In [A11], Liang *et al.* propose a recurrent neural network-based collaborative filtering method called RNCF for QoS prediction. Specifically, a multi-layer GRU structure is incorporated in the framework of neural collaborative filtering to model the dynamic state of physical environments or network conditions and share the invocation records across different time slices.

In [A12], Kumar *et al.* propose a traffic-light scheduling framework utilizing the deep reinforcement learning technique to balance the traffic flow and prevent congestion in dense regions of the city via a software-defined control interface. In software-defined control-enabled deep reinforcement learning (SDDRL), a software-defined control-enabled architecture is proposed considering traffic light controllers as control nodes that lie on the control plane, other roadside units/sensors as normal sensor nodes that lie on the data plane, and a traffic cloud as a control server. It regularly monitors the traffic conditions and generates traffic light control signals accordingly. For intelligent traffic light control signals, a deep reinforcement learning model is proposed to switch traffic light control signals in different phases, i.e., red, green, and yellow. This model takes vehicular dynamics as inputs from the real-time traffic environment such as heterogeneous vehicle count, speed, etc., and it generates control signals by learning vehicular dynamics in the coordination of the control server. SDDRL is evaluated through a realistic simulation on the Gwalior city map of India utilizing a well-known open-source simulator, i.e., SUMO.

In [A13], Zhu *et al.* addressed the problem of resource management in vehicular edge computing. The authors study how the computation resources can be optimally managed. The competitive interactions between the VEC servers and vehicles are formulated as a two-stage Stackelberg game. A game-based scheme is proposed to achieve game equilibrium for the scenario that vehicles share their computation demands. A deep reinforcement learning-based scheme is proposed for the scenario that the vehicles do not want to share personal information with other vehicles.

In [A14], Zhang *et al.* constructed a collective cumulative effect prediction of train delay model TSTGCN to predict the arrival delays of one station in a certain period. The proposed model fully considers temporal and spatial dependence. A real graph of China's high-speed railway network is constructed, which includes not only all the stations but also the mileage information of the routes. A 16-week actual operation dataset of China's high-speed railway is also built in this article, containing 1,954,176 delay records from October 8, 2019, to January 27, 2020, 727 stations, and all the routes between the stations.

In [A15], Wu *et al.* presented a novel augmented machine learning approach to improve the prediction accuracy of multi-scenario real-time train delays, including regular and irregular train delays. The method consists of a delay status labeling (DSL) algorithm and the resilience of section (RSE) and resilience of station (RST) indicators.

In [A16], Jiang *et al.* propose a probabilistic-trip-based destination prediction method named P3M in the dockless bike-sharing system. P3M uses POIs as virtual docks to tackle the absence of docks and uses the statistical features of previous records to deal with sparsity.

In [A17], Haliem *et al.* introduce an adaptive model-free deep reinforcement approach that can recognize and adapt to the diurnal patterns in the ride-sharing environment with car-pooling. Rather than fixing patterns by the time of the week, the proposed approach automatically detects that the MDP has changed, and uses the results of the new model.

In [A18], Emami *et al.* introduced a single lightweight CNN architecture for multi-object tracking that runs on low-power devices such as CPUs. A simple algorithm for fusing video tracks with a commercial traffic radar is proposed as well. The core idea is to first track distant vehicles with the radar and then "hand-off" tracks to the video tracker, which is more accurate at distances close to the traffic intersection. The performance of the CNN architecture and multi-sensor tracking framework is analyzed on multi-sensor data collected and labeled from a live intersection.

In [A19], Kim and Kwon present a novel dehazing framework for real-world images that contain both hazy and low-light areas. Dehazing and low-light enhancements are unified using an illumination map that is estimated using a proposed convolutional neural network. The illumination map is then used as a component for three different tasks: atmospheric light estimation, transmission map estimation, and low-light enhancement, thereby enabling the solving of interrelated low-level vision problems simultaneously. To train the neural network to perform both dehazing and low-light enhancement, the authors synthesize hazy and low-light images from normal images.

In [A20], Pham *et al.* adopt the generative adversarial imitation learning (GAIL) algorithm for aircraft taxi-speed modeling, while considering multiple operational factors including surrounding traffic on the ground and target take-off time. The proposed approach can learn and reproduce the ground movement patterns in a real-world dataset under different circumstances. In addition, the characteristics of the taxi-speed model are also analyzed, especially focusing on handling conflict scenarios with surrounding traffic. The trained model outperforms all the baseline models with a significant margin for both spatial and temporal completion.

In [A21], Abdel-Basset *et al.* introduce a federated deep-learning framework (FED-IDS) for efficient detection of cyber-attacks via offloading the learning process from servers to distributed vehicular edge nodes. FED-IDS presents a context-aware transformer network to learn spatial–temporal representations of vehicular traffic flow necessary for classifying different categories of attacks. Blockchain-managed federated training is introduced to enable multiple edge nodes to offer secure, distributed, and reliable training without the need for centralized authority. The distributed local updates from participating vehicles are confirmed by miners to stop unreliable updates from being deposited on the blockchain.

In [A22], Karnati *et al.* show that neural networks can be used to effectively leverage the waveforms collected at stopbar and advanced detectors to model the traffic dynamics both at an intersection and across intersections. The authors show that modeling of these waveforms can be useful to understand traffic flow dynamics under different signal timing plans and can be potentially integrated into signal timing optimization software.

In [A23], Luo *et al.* developed a high-fidelity simulation environment that enables fine-grained simulation of the operation and infrastructure deployment of the shared e-mobility system in the real world. A multi-agent deep neural search approach is presented to discover the optimal deployment strategy. It features a hierarchical controller that iteratively proposes tentative deployment plans, evaluates their performance in simulation, and adjusts its parameters to generate better strategies in future iterations.

In [A24], Cheng *et al.* introduce a transferable sea state estimation model aiming at the challenges: 1) enough data for training a model; 2) model generalization. The proposed model focuses on knowledge transfer when the collected data for the source marine system is sufficient but the collected data of the target marine system is scarce. A data pairing algorithm is proposed to determine the relationship between the source and the target marine system. Based on these paired data, a Siamese convolutional neural network, including a new proposed residual fully convolutional network and two novel attention modules, is designed for semantic alignment.

In [A25], Chandra *et al.* present an approach that leverages machine learning to predict, the behaviors of human drivers. This is similar to how humans implicitly interpret the behaviors of drivers on the road, by only observing the trajectories of their vehicles. We use graph-theoretic tools to extract driver behavior features from the trajectories and machine learning to obtain a computational mapping between the extracted trajectory of a vehicle in traffic and the driver behaviors. Compared to prior approaches in this domain, we prove that our method is robust, general, and extendable to broad-ranging applications such as autonomous navigation.

In [A26], Xu *et al.* proposed a novel end-to-end irregular license plate recognition (EILPR) system to detect and recognize the license plate (LP) of multi-line text or arbitrary shooting angles, using only plate-level annotations for training. In EILPR, a new automatic perspective alignment layer (APAN) is also proposed to extract the fine LP features connecting the detection and recognition. For recognition, a location-aware 2D attention based recognition network is performed to recognize the multi-line and multinational LP based on the extracted features.

In [A27], Fernandez *et al.* propose a forensic technique by analyzing compression algorithms used by the H.264 coding. The presence of recompression uses information of macroblocks, a characteristic of the H.264-MPEG4 standard, and motion vectors. A vector support machine is used to create the model that allows to accurately detect if a video has been recompressed.

In [A28], Zhang *et al.* propose to extract dynamic context from event-based data with a higher temporal resolution to enhance static RGB images, even for those from traffic accidents with motion blur, collisions, deformations, overturns, etc. Moreover, to evaluate the segmentation performance in traffic accidents, we provide a pixel-wise annotated accident dataset, namely DADA-seg, which contains a variety of critical scenarios from traffic accidents.

In [A29], Huo *et al.* propose a novel text-to-traffic generative adversarial network framework, which fuses the traffic data and the semantic information collected from social media to generate the traffic situation.

In [A30], Hoffmann *et al.* aim to design REM, to support the selection of secondary spectrum channels for intra-platoon communications. The authors propose to assess the channel's quality in terms of outage probability computed, with the use of estimated interference distributions stored in REM. A frequency selection algorithm that minimizes the number of channel switches along the planned platoon route is proposed. In addition, the REM creation procedure is shown that reduce the number of database entries using the (density-based spatial clustering of applications with noise) DBSCAN algorithm.

In [A31], Tan *et al.* are concerned with the HSR–air timetable coordination (HATC) problem to synchronize high-speed railway (HSR) and aviation services to adapt inter-modality traffic needs. This problem is solved by rescheduling the HSR timetable to attract the maximum HSR–air passenger flow, and at the same time, considering the minimum adjustments to the initial HSR timetable. The HATC problem is an integration of train timetable rescheduling and HSR-air passenger flow predicting problem. There is a trade-off increasing the HSR–air passenger flow and the adjustments to the initial train timetable. To capture the complex feature interactions of passenger flow impact features, an HSR–air passenger flow prediction model is proposed using a factorization machine and deep neural networks. Moreover, this passenger flow prediction model then is integrated into the train timetable rescheduling model to calculate the passenger flow under different HSR–air service networks.

In [A32], Villalba *et al.* propose the application of different clustering algorithms for monitoring software defined networks to validate the number of statistics queries decrements using the data and error rates to improve the network traffic and to reduce the overload.

In [A33], Liu *et al.* propose a lightweight tensor DCM. The model compresses the redundant learning parameters of the model and reduces the consumption of computational resources while maintaining the learning characterization capability of the DCM in tensor space, thus making the network model more general and lightweight for deploying the DCM to smart cars and edge devices.

Predicting the actual intended destination in online travel platforms is challenging. To address this, a deep multi-sequences fused neural network (DMSN) learned from the user behaviors was proposed in [A34] by Li *et al.* The experimental results in this article indicated that the proposed DMSN models can achieve high intention destination prediction accuracy.

TAI-HOON KIM
School of Economics and Management
Beijing Jiaotong University
Beijing 100044, China

APPENDIX: RELATED ARTICLES

[A1] F. Zhou, X. J. Yang, and J. C. F. de Winter, "Using eye-tracking data to predict situation awareness in real time during takeover transitions in conditionally automated driving," *IEEE Trans. Intell. Transp. Syst.*, early access, Apr. 6, 2021, doi: 10.1109/TITS.2021.3069776.

[A2] X. Li, J. Wei, and H. Jiao, "Real-time tracking algorithm for aerial vehicles using improved convolutional neural network and transfer learning," *IEEE Trans. Intell. Transp. Syst.*, early access, May 7, 2021, doi: 10.1109/TITS.2021.3072872.

[A3] J. Li, L. Xin, Z. Cao, A. Lim, W. Song, and J. Zhang, "Heterogeneous attentions for solving pickup and delivery problem via deep reinforcement learning," *IEEE Trans. Intell. Transp. Syst.*, early access, Feb. 10, 2021, doi: 10.1109/TITS.2021.3056120.

[A4] A. K. Sutrala, M. S. Obaidat, S. Saha, A. K. Das, M. Alazab, and Y. Park, "Authenticated key agreement scheme with user anonymity and untraceability for 5G-enabled softwarized industrial cyber-physical systems," *IEEE Trans. Intell. Transp. Syst.*, early access, Feb. 17, 2021, doi: 10.1109/TITS.2021.3056704.

[A5] S. Zhang, M. Abdel-Aty, Y. Wu, and O. Zheng, "Pedestrian crossing intention prediction at red-light using pose estimation," *IEEE Trans. Intell. Transp. Syst.*, early access, May 4, 2021, doi: 10.1109/TITS.2021.3074829.

[A6] D. Lin, M. Chen, H. Chiang, and P. K. Sharma, "Intelligent traffic accident prediction model for internet of vehicles with deep learning approach," *IEEE Trans. Intell. Transp. Syst.*, early access, May 5, 2021, doi: 10.1109/TITS.2021.3074987.

[A7] K. Zhang, X. Jiang, and J. Ma, "Appearance-based loop closure detection via locality-driven accurate motion field learning," *IEEE Trans. Intell. Transp. Syst.*, early access, Jun. 16, 2021, doi: 10.1109/TITS.2021.3086822.

[A8] A. Derhab, M. Belaoued, I. Mohiuddin, F. Kurniawan, and M. K. Khan, "Histogram-based intrusion detection and filtering framework for secure and safe in-vehicle networks," *IEEE Trans. Intell. Transp. Syst.*, early access, Jun. 23, 2021, doi: 10.1109/TITS.2021.3088998.

[A9] Y. Zhu, Y. Liu, J. J. Q. Yu, and X. Yuan, "Semi-supervised federated learning for travel mode identification from GPS trajectories," *IEEE Trans. Intell. Transp. Syst.*, early access, Aug. 16, 2021, doi: 10.1109/TITS.2021.3092015.

[A10] T. Wen, G. Xie, Y. Cao, and B. Cai, "A DNN-based channel model for network planning in train control systems," *IEEE Trans. Intell. Transp. Syst.*, early access, Jul. 14, 2021, doi: 10.1109/TITS.2021.3093025.

[A11] T. Liang, M. Chen, Y. Yin, and L. Zhou, "Recurrent neural network based collaborative filtering for QoS prediction in IoV," *IEEE Trans. Intell. Transp. Syst.*, early access, Aug. 11, 2021, doi: 10.1109/TITS.2021.3099346.

[A12] N. Kumar, S. Mittal, V. Garg, and N. Kumar, "Deep reinforcement learning-based traffic light scheduling framework for SDN-enabled smart transportation system," *IEEE Trans. Intell. Transp. Syst.*, early access, Aug. 11, 2021, doi: 10.1109/TITS.2021.3095161.

[A13] X. Zhu, Y. Luo, A. Liu, and N. Xiong, "A deep reinforcement learning-based resource management game in vehicular edge computing," *IEEE Trans. Intell. Transp. Syst.*, early access, Sep. 27, 2021, doi: 10.1109/TITS.2021.3114295.

[A14] D. Zhang, Y. Peng, Y. Zhang, D. Wu, H. Wang, and H. Zhang, "Train time delay prediction for high-speed train dispatching based on spatio-temporal graph convolutional network," *IEEE Trans. Intell. Transp. Syst.*, early access, Aug. 11, 2021, doi: 10.1109/TITS.2021.3097064.

[A15] J. Wu *et al.*, "The bounds of improvements toward real-time forecast of multi-scenario train delays," *IEEE Trans. Intell. Transp. Syst.*, early access, Aug. 3, 2021, doi: 10.1109/TITS.2021.3099031.

[A16] M. Jiang, C. Li, K. Li, and H. Liu, "Destination prediction based on virtual poi docks in dockless bike-sharing system," *IEEE Trans. Intell. Transp. Syst.*, early access, Aug. 30, 2021, doi: 10.1109/TITS.2021.3099571.

[A17] M. Haliem V. Aggarwal, and B. Bhargava, "Adapool: A diurnal-adaptive fleet management framework using model-free deep reinforcement learning and change point detection," *IEEE Trans. Intell. Transp. Syst.*, early access, Oct. 8, 2021, doi: 10.1109/TITS.2021.3109611.

[A18] P. Emami, L. Elefteriadou, and S. Ranka, "Long-range multi-object tracking at traffic intersections on low-power devices," *IEEE Trans. Intell. Transp. Syst.*, early access, Oct. 4, 2021, doi: 10.1109/TITS.2021.3115513.

[A19] G. Kim and J. Kwon, "Deep illumination-aware dehazing with low-light and detail enhancement," *IEEE Trans. Intell. Transp. Syst.*, early access, Oct. 12, 2021, doi: 10.1109/TITS.2021.3117868.

[A20] D. Pham, T. Tran, and S. Alam, "A generative adversarial imitation learning approach for realistic aircraft taxi-speed modeling," *IEEE Trans. Intell. Transp. Syst.*, early access, Oct. 15, 2021, doi: 10.1109/TITS.2021.3119073.

[A21] M. Abdel-Basset, N. Moustafa, and H. Hawash, "Federated intrusion detection in blockchain-based smart transportation systems," *IEEE Trans. Intell. Transp. Syst.*, early access, Oct. 26, 2021, doi: 10.1109/TITS.2021.3119968.

[A22] Y. Karnati, R. Sengupta, A. Rangarajan, and S. Ranka, "Subcycle waveform modeling of traffic intersections using recurrent attention networks," *IEEE Trans. Intell. Transp. Syst.*, early access, Nov. 13, 2021, doi: 10.1109/TITS.2021.3121250.

[A23] M. Luo, B. Du, K. Klemmer, H. Zhu, and H. Wen, "Deployment optimization for shared e-mobility systems with multi-agent deep neural search," *IEEE Trans. Intell. Transp. Syst.*, early access, Nov. 16, 2021, doi: 10.1109/TITS.2021.3125745.

[A24] X. Cheng, G. Li, P. Han, R. Skulstad, S. Chen, and H. Zhang, "Data-driven modeling for transferable sea state estimation between marine systems," *IEEE Trans. Intell. Transp. Syst.*, early access, Nov. 30, 2021, doi: 10.1109/TITS.2021.3129916.

[A25] R. Chandra, A. Bera, and D. Manocha, "Using graph-theoretic machine learning to predict human driver behavior," *IEEE Trans. Intell. Transp. Syst.*, early access, Dec. 10, 2021, doi: 10.1109/TITS.2021.3130218.

[A26] H. Xu, X. D. Zhou, Z. Li, L. Liu, C. Li, and Y. Shi, "EILPR: Toward end-to-end irregular license plate recognition based on automatic perspective alignment," *IEEE Trans. Intell. Transp. Syst.*, early access, Dec. 3, 2021, doi: 10.1109/TITS.2021.3130898.

[A27] E. G. Fernández, A. L. S. Orozco, and L. J. G. Villalba, "Digital video manipulation detection technique based on compression algorithms," *IEEE Trans. Intell. Transp. Syst.*, early access, Dec. 30, 2021, doi: 10.1109/TITS.2021.3132227.

[A28] J. Zhang, K. Yang, and R. Stiefelhagen, "Exploring event-driven dynamic context for accident scene segmentation," *IEEE Trans. Intell. Transp. Syst.*, early access, Dec. 21, 2021, doi: 10.1109/TITS.2021.3134828.

[A29] G. Huo, Y. Zhang, B. Wang, and Y. Hu, "Text-to-traffic generative adversarial network for traffic situation generation," *IEEE Trans. Intell. Transp. Syst.*, early access, Dec. 24, 2021, doi: 10.1109/TITS.2021.3136143.

[A30] M. Hoffmann, P. Kryszkiewicz, and A. Kliks, "Frequency selection for platoon communications in secondary spectrum using radio environment maps," *IEEE Trans. Intell. Transp. Syst.*, early access, Dec. 24, 2021, doi: 10.1109/TITS.2021.3136681.

[A31] Y. Tan, Y. Li, R. Wang, X. Mi, Y. Li, and H. Zheng, "Improving synchronization in high-speed railway and air intermodality: Integrated train timetable rescheduling and passenger flow forecasting," *IEEE Trans. Intell. Transp. Syst.*, early access, Jan. 6, 2021, doi: 10.1109/TITS.2021.3137410.

[A32] L. J. G. Villalba, J. A. P. Fernández, and A. L. S. Orozco, "Analysis of MP4 videos in 5G using SDN," *IEEE Trans. Intell. Transp. Syst.*, early access, Feb. 1, 2022, doi: 10.1109/TITS.2022.3143159.

[A33] D. Liu, L. T. Yang, R. Zhao, J. Wang, and X. Xie, "Light weight tensor deep computation model with its application in intelligent transportation systems,"

[A34] Y. Li, F. Xiong, Z. Wang, Z. Chen, C. Xu, Y. Yin, and L. Zhou, "Spatial-temporal deep intention destination networks for online travel planning," *IEEE Trans. Intell. Transp. Syst.*, early access, Aug. 3, 2021, doi: 10.1109/TITS.2021.3091534.