Guest Editorial
Introduction to the Special Issue on Advanced Signal Processing and AI Technologies for Transportation Big Data and Their Applications in COVID-19 Scenario and Beyond

COMPARED with the traditional transportation data, the transportation big data (TBD) is under the background of "Internet + traffic." It is a great challenge for analyzing and processing TBD because of its complex and unstructured characteristics, such as sequence, strong relevance, accuracy, and closed loop. This Special Issue provides high-quality and up-to-date technology related to the application of SP and AI into TBD and their applications in the COVID-19 scenario and beyond and serves as a forum for researchers all over the world to discuss their works and recent advancements in the field, especially for defensing COVID-19 in public transportation.

For the record, 27 papers were accepted for publication. to our open call for papers on Special Issue. These papers were rigorously evaluated according to the normal reviewing process of the IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS. The evaluation process took into consideration factors pertaining to originality, technical quality, presentational quality, and overall contribution. Below is a brief introduction to each of them.

In [A1], Wang et al. regard the channel estimation problem as the sparse channel recovery and propose a multipath simultaneous matching tracking estimation method. It is assumed that the noise between the practical channels has a certain correlation, and the noise correlation has an impact on the selection of the optimal atomic support set in the process of channel recovery. Therefore, noise weighting is introduced in our proposed method. The simulation results prove the validity of our proposed method in frequency-selective mmWave MIMO channels. Without increasing the complexity of the algorithm, the proposed method can achieve better local performance than the traditional classical methods.

In [A2], Shao et al. develop an estimation method to obtain human co-location levels from mobility trajectory data, and then extend the epidemic model with real-time co-location levels to forecast the transmission of epidemic, and applies them to evaluate the effect of various mobility restrictions. The empirical results and simulations corroborated the theoretical analysis, providing effective guidance to contain the pandemic.

In [A3], Guo et al. propose an XGBoost-LSTM mixed framework that predicts the spread of infectious diseases in multiple cities and regions. According to big traffic data, it was found that population flow is closely related to the spread of infectious diseases. Clustering and dividing cities according to population flow can significantly improve prediction accuracy. Meanwhile, an XGBoost is used to predict the transmission trend based on the key features of infection. An LSTM is used to predict the transmission fluctuation based on infection-related multiple time series features. The mixed model combines transmission trends and fluctuations to predict infections accurately.

In [A4], Gao et al. propose a novel Tree-based BLS (TBLS) intrusion detection method according to the idea of ensemble learning and decision tree (CART and J48). The performance of TBLS was tested on the NSL-KDD and the UNSW-NB15 datasets, respectively, which contain a variety of malicious traffic types for attacks on the IoV. The results show that our proposed method can achieve higher accuracy and lower false positive rates compared to 16 existing solutions.

In [A5], Li et al. advocate a self-localization method based on the weighted direct position determination (DPD) method that eliminates non-homogeneity among different emitters, and furtherly proposes a weighted cascade compensation estimator (WCCE) to reduce the computation complexity, which can be readily extended to target tracking applications. Joint Collaborative Big Spectrum Data Sensing and Reinforcement Learning Based Dynamic Spectrum Access for Cognitive Internet of Vehicles.

In [A6], Liu et al. present to increase spectrum utilization while avoiding harmful interference to the primary user (PU). Collaborative big spectrum data sensing is presented to achieve accurate spectrum data by allowing multiple vehicles to sense for PUs' activities in different geographical areas. A Q-learning-based spectrum access algorithm is proposed to improve the spectrum access performance of CIoV via intelligently allocating spectrum resources.

In [A7], Guo et al. introduced the target parameter estimation in traffic, frequency diversity array multiple-input multiple-output (FDA-MIMO) radar into ITS, and tensor decomposition is used to process TBD to improve the real-time performance of target location estimation. Unfortunately, spatial colored noise and array gain-phase error will affect the performance of FDA-MIMO radar in ITS. An algorithm that

Digital Object Identifier 10.1109/TITS.2023.3348941

can solve the angle-range estimation problem of FDA-MIMO radar in the co-existence of array gain-phase error and spatial colored noise is proposed. Firstly, the four-dimensional tensor is constructed by using the temporal un-correlation of colored noise. Therefore, the influence of colored noise in ITS is removed. Secondly, the direction matrix containing target information is obtained by parallel factor (PARAFAC) decomposition. For the array gain-phase error, the optimization problem is constructed, and the Lagrange multiplier is employed to calculate the optimal solution. The effect of the gain-phase error is eliminated by utilizing the optimal solution and the direction matrices. Finally, the location information of motor vehicle is achieved by calculating the solution of least square (LS) fitting. The developed scheme can achieve the location information of motor vehicles in the co-existence of array gain-phase error and spatial colored noise.

In [A8], Zhang et al. present a large-scale resource scheduling algorithm of WSNs based on multi-objective evolutionary optimization to improve the performance of WSNs. A multi-index service quality evaluation model including coverage, connectivity, energy efficiency is developed to characterize the comprehensive performance of WSNs firstly. Afterward, a multi-objective resource scheduling algorithm is proposed to optimize the above complex model. A differential ion coevolution strategy and a fast individual selection strategy based on multi-objective decomposition are presented in specific. The comparative experimental results show that the performance of WSNs on multiple indicators obtained by the proposed algorithm has been improved considerably.

In [A9], Wu et al. present a three-layered TBD task processing architecture with a federated learning mechanism for credit priority-based task scheduling and running. The architecture considers the efficiency of task offloading and misbehavior attack problems simultaneously. To preserve the privacy of vehicles and obtain the related features for vehicular credit prediction, the vehicular federated learning framework combined with Multi-Layer Perceptron (MLP) is used for credit measurement. The proposed solution can prioritize tasks and assign sufficient resources for reliable and active task requesters.

In [A10], Aydin et al. first, the regions are divided into grids and different importance values are assigned according to the number of buildings that are likely to be damaged and are vital for the response stage. Second, these importance levels are updated based on day and time. Third, the depots are selected among the predetermined candidate locations. Fourth, detection times at grids are considered as uncertain parameters. Fifth, two versions of Ant Colony Optimization (ACO) are developed. Last, sensitivity analyzes are performed by reducing the number of sorties, drones, and by comparing day and night importance values. Exact solution tool was able to reach the optimal only for very small-scale instances, while both versions of ACO reached to similar results within less CPU times. ACO algorithms also found good results for larger problem instances.

In [A11], Gu et al. present a new semi-supervised multi-view sparse regularization and graph embedding learning model for EEG-based driver mental fatigue recognition in COVID-19 Scenario. Facing the challenge of the massive emergence of driver EEG multi-view data only with limited label information, sparse regularization embedding and graph embedding technology is adopted to describe the data distribution structure. The common shared regularization embedding factor and private regularization embedding factor is also introduced to preserve the consistency and diversity of the multi-view data. Furthermore, kernel trick is adopted to extend the proposed model to the nonlinear version. Due to high recognition ability, the proposed model can accurately recognize EEG-based driver mental fatigue.

In [A12], Rajput et al. present a seamless multi-module multi-layer vehicular cloud computing system developed using resources of parked vehicles, cloud computing facilities, and vehicular networking technologies. It can offer transportation-specific AI and Big data-empowered services to on-road vehicles. As use cases, we present two innovative and improved services, vehicular Big data mining and vehicular route optimization. A physical testbed is formed to show the feasibility of this work. Results analysis shows that the systems perform better than the standalone systems and servers under different scenarios. Relevant fundamental challenges and future outlooks are also highlighted in this work.

In [A13], Wang et al. present a MOBO with block coordinate updates, Block-MOBO, to solve high-dimensional expensive MOPs. Block-MOBO first partitions the decision variable space into different blocks, each of which includes a low-dimensional MOP. At each iteration, one block is considered and the decision variables not in this block are approximated by context-vector generation embedded with the Pareto prior knowledge thus promoting convergence. To tackle the boundary issue, we present ϵ-greedy acquisition function in a Bayesian and multi-objective fashion, which recommends candidates either from the exploitation-exploration trade-off perspective or with probability ϵ from the Pareto dominance relationship perspective. We compare Block-MOBO with other multi-objective Bayesian methods on two r transportation system problems and three multi-objective synthetic benchmarks. The experimental results show that Block-MOBO can find more evenly distributed and non-dominated solutions with lower complexity compared with other baselines. Our analyses illustrate that block coordinate updates and ϵ-greedy acquisition function contribute to computational complexity reduction and convergence-diversity trade-offs, respectively.

In [A14], Nie et al. propose a network traffic prediction algorithm aiming at time-varying traffic flows with a large number of fluctuations. This algorithm combines Deep Q-Learning (DQN) and Generative Adversarial Networks (GAN) for network traffic feature extraction. DQN is leveraged to carry out network traffic prediction, in which GAN is involved to represent Q-network. Meanwhile, the generative network can increase the number of samples to improve the prediction error. We evaluate the performance of our method by implementing it on three real network traffic data sets. Finally, we compare the two state-of-the-art competing methods with our method.

In [A15], Gan et al. proposed a new dynamic parameter-A^* (DP-$A*$) algorithm, which is based on the A^* algorithm and enables the UGV to continuously optimize the path while performing the same task repeatedly. First, the original evaluation functions of the A* algorithm are modified by Q-learning to memory the coordinates of unknown obstacle. Then, Q-table is adopted as an auxiliary guidance for recording the characteristics of environmental changes and generating heuristic factor to overcome the shortcoming of the A* algorithm. At last, the DP-A* algorithm can realize path planning in the instantaneous changing environment, record the actual situation of obstacles encountered, and gradually optimize the path in the task that needs multiple explorations.

In [A16], Zhu et al. proposed a novel two-stage model to tackle this issue. To reduce the dimensionality, the inflows of all stations are predicted in the first stage by Long Short-Term Memory (LSTM) in real time. In the second stage, the separation rate, namely, the proportion of inbound passengers bounding for another station, is objectively estimated. Finally, the OD flow is predicted based on the inflow and separation rate. Experiments on Hangzhou Metro dataset show the proposed model outperforms the contrast model in both accuracy and efficiency.

In [A17], Zha et al. address a significant challenge in the context of COVID-19: the specific emitter identification (SEI) of aircraft using their Radio Frequency (RF) signals. SEI is essential for tracking and identifying individual aircraft, which is particularly crucial during a pandemic for monitoring and managing air traffic. The challenge in applying deep learning (DL) techniques to SEI lies in the low-resource scenarios, primarily due to the long-tailed distribution of aircraft signal data. This distribution results in a data imbalance, making it difficult to train DL models effectively. To overcome this, the paper introduces a novel method named long-tailed specific emitter identification (LT-SEI), which employs decoupled representation (DR) learning. This method bifurcates the learning process into two distinct phases: first, the representation learning phase, and then the classification phase. The focus here is on managing the unbalanced training data more effectively and implementing balanced classifier learning.

In [A18], Zhang et al. model the mission planning problem in the uncertain dynamic environment as a dynamic multi-constraint and multi-objective optimization problems (DMCMOP) and propose the dynamic constrained two-archive evolutionary algorithm (DCTAEA) to realize the efficient mission planning. The proposed method can reconstruct the convergence archive (CA) and the diversity archive (DA) adaptively, and introduce the dynamic self-adaptive penalty mechanism into the CA updating, DA updating and the mating selection, which utilizes valuable infeasible solutions and promote population convergence. Consequently, the proposed algorithm can balance convergence, diversity and feasibility simultaneously. Comprehensive experiments on the real scenes and benchmark problem demonstrate that, compared with state-of-the-art algorithms, the proposed algorithm has the superiority and effectiveness.

In [A19], Geng et al. propose a communication-efficient semi-asynchronous parallel mechanism (SAP-SGD), which can take full advantage of the acceleration effect of asynchronous strategy on heterogeneous training and constrain the straggler problem by using global interval synchronization. Additionally, a solution for heterogeneous communication and a weighted aggregation strategy for model parameters are designed. Experimental results demonstrate the performance of the proposed framework.

In [A20], Liu et al. proposed a new double level attack method. By constructing the dynamic iterative step size and analyzing the class characteristics of the signals, this method can use the adversarial losses of feature layer and decision layer to generate adversarial examples with stronger attack performance. In order to improve the robustness of the recognition model, adversarial training and transfer learning are applied to the jamming recognition models in wireless communication environments. Simulation results show that the proposed attack and defense methods have good performance.

In [A21], Lin et al. propose two unknown COTS RFID tag identification approaches to rapidly identify unregistered vehicles in the RFID- assisted intelligent transportation systems. Firstly, a Single-Point Selective unknown tag identification approach called SPS is proposed, which adopts an analog hash pattern exclusively to identify unknown tags. Then a Multi-Point Selective unknown tag identification approach called MPS is proposed, in which two techniques of batch identification and batch division are developed to reduce the number of empty slots and avoid tag collisions, respectively. The identification efficiency can be maximized via extensive theoretical analysis. Finally, both the simulations and COTS RFID device based experiments validate the effectiveness of the proposed approaches.

In [A22], Jiang et al. proposed a novel algorithm for high-resolution imagery of point clouds with extremely high Doppler and angle resolutions in this paper. For high Doppler resolution with high-dynamic, a novel velocity ambiguity resolution algorithm is proposed using a dual pulse repetition frequency (dual-PRF) waveform design embedded in an innovative time-division multiplexing & Doppler-division multiplexing MIMO (TDM-DDM-MIMO) framework. Meanwhile, an attractive complex-valued deep convolutional network (CV-DCN) of super-resolution direction-of-arrival (DOA) estimation is proposed only using single-frame data. Specifically, a spatial smoothing operator on array data is applied as input of the network, and a CV-DCN is designed to learn the transformation of the spatial spectrum from the end-to-end to effectively protect the spectrum extraction.

In [A23], Cai et al. provide real-time response by alleviating data transmission between data sources and cloud servers and fully utilizes smart devices by exploring their computing capacity. Therefore, we design RIDIC, an intelligent transportation system with dispersed computing to provide a real-time response when processing transportation big data. RIDIC abstracts all the heterogeneous smart roadside devices as actors, and its workflow consists of three stages, Actor Registration, Resource Application and Task Execution. We conduct experiments on two real-life traffic scenarios—road vehicle detection and traffic signal recognition—and the results show that RIDIC can utilize edge devices to process transportation big data faster while reducing the demand for device computing resources.

In [A24], Meng et al. introduced an architecture for vehicle position estimation to tackle the issue of vehicles positioning in traffic congestion of intelligent transportation system (ITS). The introduced architecture is related to three unmanned aerial vehicles (UAVs) equipped with uniform linear array (ULA), and the ITS center store data and the terminal is responsible for executing the corresponding direction of arrival (DOA) estimation algorithm to estimate the vehicle position. Then, a robust sparse recovery framework based on the optimal weighted subspace fitting is put forward for DOA estimation in the presence of direction-dependent unknown mutual coupling. Then, the position of vehicles is estimated by a weighted three-points correspositioning method. The results of various simulation experiments fully demonstrate the robustness and superiority of the proposed architecture and algorithm.

In [A25], Zheng et al. proposed a novel learning improvement heuristic algorithm to effectively solve multi-objective route planning (MORP) problems. This algorithm utilizes a population-based mechanism to approximate the Pareto Front (PF) by employing heuristic operators, which are assisted by a single deep reinforcement learning model. This algorithm is the first learning improvement heuristic algorithm for MORP. Experimental results demonstrate its efficiency compared to learning construction methods.

In [A26], Zhu et al. firstly constructed a Graph Evaluation and Review Technique Simulation Evolution Network to describe the coupling effects between emergencies and chain evolution of emergencies. Considering the internal and external influencing factors of the emergency chain, a dynamic evolution model of the emergency chain based on Coupled Map Lattice is proposed. Simulation results show that the model can better reflect the dynamic evolution rules of emergency chain.

In [A27], Peng et al. proposed an online scheduling method for TT flows (RFSD), which uses Lion Swarm Optimization (LSO) algorithm for priority assignment and dynamic queues to adjust the scheduling order in real time. It ensures fairness in scheduling and effectively improves the utilization of time slot resources. Furthermore, an online scheduling method for AVB flows (RFSU) is proposed, which uses the Imperialist Competitive Algorithm (ICA) to construct the utility function for evaluating the scheduling value of AVB flows, effectively increasing the throughput of AVB flows. Finally, extensive experiments show that RFSD increases successful scheduling by 22% over the PAS algorithm. Compared to the TTA algorithm, RFSU achieves a 24% reduction in average delay and a 27% reduction in jitter.

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APPENDIX: RELATED ARTICLES

[A1] H. Wang, P. Xiao, and X. Li, “Channel parameter estimation of mmWave MIMO system in urban traffic scene: A training channel-based method,” *IEEE Trans. Intell. Transp. Syst.*, early access, Feb. 1, 2022, doi: 10.1109/TITS.2022.3145363.

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