Guest Editorial Optimization of Electric Vehicle Networks and Heterogeneous Networking in Future Smart Cities

WITH the development of 5G communication and transportation infrastructure, transportation systems face challenges to serve future smart cities regarding effective operation and cost optimization for electric vehicle networks. Thus, heterogeneous networking optimization approaches for these vehicles have been investigated, which have great potential in real-time communications, intelligent processing, reliable understanding, and efficient management. The guest editors have selected 16 articles for review in this special issue. A summary of these articles is outlined below.

The article entitled "Big data analysis technology for electric vehicle networks in smart cities," by Lv *et al.*, explores electric vehicle networks in smart cities through big data analysis technology. This study utilizes K-means and fuzzy theory with big data analysis technology to construct an objective function-based fuzzy mean clustering algorithm theory (FCM). The resulting FCM algorithm is improved, and an electric vehicle network is simulated. In an analysis of the route guidance effects, when facing congested road sections, the route guidance strategy of this study can effectively restrain the spread of congestion and achieve the timely amelioration of traffic congestion. In a further analysis of the impact of different factors on traffic conditions, under route guidance, with the increase in the market penetration rate (MPR) of devices, the following rate (FR) of vehicles, and the congestion level (CL), the improvement of the induction strategy becomes clearer, and greater economic benefits are achieved. This study has found that utilizing big data analysis techniques to improve electric vehicle transportation networks can reduce the network data transmission performance delay significantly and change traffic patterns to suppress the spread of congestion effectively, which has provided experimental references for the development of electric vehicle transportation networks.

The article entitled "Cross-data set transfer driver expression recognition via global discriminative and local structure knowledge exploitation in shared projection subspace," by Xia *et al.*, proposes a novel approach for cross-data set transfer driver expression recognition via global discriminative and local structure knowledge exploitation in a shared projection subspace (GD-LS-SS). By learning a shared common subspace, GD-LS-SS utilizes the local geometrical data structure by exploiting the knowledge of graph topology and the global discriminative information by using the pairwise constrained knowledge between the source and labeled target data. Taking advantage of the kernel trick, a kernel version of GD-LS-SS is proposed to learn the kernel projection for handling nonlinear cross-data set transfer and to further promote recognition accuracy. Experiments on the KMU-FED data set show that the satisfactory recognition performance of GD-LS-SS outperforms several traditional nontransfer and related transfer approaches.

The article entitled "An edge traffic flow detection scheme based on deep learning in an intelligent transportation system," by Chen *et al.*, proposes a traffic flow detection scheme based on deep learning on an edge node. First, they propose a vehicle detection algorithm based on the YOLOv3 (You Only Look Once) model trained with a large volume of traffic data. They prune the model to ensure its efficiency on the edge equipment. In addition, the DeepSORT (deep simple online and real-time tracking) algorithm is optimized by retraining the feature extractor for multiobject vehicle tracking. Then, they propose a real-time vehicle tracking counter for vehicles that combines vehicle detection and vehicle tracking algorithms to realize the detection of traffic flow. Finally, the vehicle detection network and multiple-object tracking network are migrated and deployed on the Jetson TX2 edge device platform, and they verify the correctness and efficiency of their framework. The test results indicate that their model can efficiently detect traffic flows with an average processing speed of 37.9 FPS (frames per second) and an average accuracy of 92.0% on an edge device.

The article entitled "EEG-based driver drowsiness estimation using an online multi-view & transfer TSK fuzzy system," by Jiang *et al.*, considers an online multiview regression model with high interpretability. By taking the first-order TSK fuzzy system as the basic regression component and injecting the nature of the multiview settings into the existing transfer learning framework and enforcing the consistencies across different views, they propose an online multiview and transfer TSK fuzzy system for estimating driver drowsiness. In this novel model, features in both the source domain and the target domain are represented from multiview perspectives such that more pattern information can be utilized during model training. Additionally, compared with offline training, the proposed online fuzzy system meets the practical requirements more competently. An experiment on a driving data set demonstrates that the proposed fuzzy system has fewer

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drowsiness estimation errors and higher interpretability than the introduced benchmarking models.

The article entitled "Enabling the wireless charging via bus network: Route scheduling for electric vehicles," by Jin *et al.*, designs a new EV charging system that leverages bus networks in urban areas through the integration of an OnLine Electric Vehicle (OLEV) system and a Microwave Power Transfer (MPT) system. They formulate an EV route scheduling problem based on this new charging system to maximize the total residual energy subject to all EVs that can arrive at their destinations before deadlines. Then, they propose an approximation algorithm, RSA, to solve the route scheduling problem. To relieve traffic congestion, they further formulate the conflict-free EV route scheduling problem and use the matching-based algorithm FRSA to find the EV route schedules with the maximal residual energy. Through extensive simulations, they demonstrate that RSA and FRSA can increase the average residual energy by 67.66% and 50.36% compared with a solution without the designed wireless charging system, respectively.

The article entitled "Energy-efficient heterogeneous networking for electric vehicles networks in smart future cities," by Jiang *et al.*, proposes an electric vehicle cloud computing framework to perform energy-efficient heterogeneous networking for electric vehicle networks in smart future cities. Software-defined networking ideas are used to enable different devices, including electric vehicles, to access a cloud computing network for connected electric vehicles. Edge computing is exploited to run rapid computing and communication for these applications. Then, an energy-efficient heterogeneous networking method is presented to overcome high energy consumption. A mixed-integer linear programming optimization model and two heuristic models are proposed to perform energy-efficient networking. A networking algorithm is proposed to achieve highly energy-efficient networking for electric vehicle networks. Detailed simulation experiments are conducted to validate their approach. Simulation results illustrate that the proposed method is efficient and feasible.

The article entitled "Internet of Vehicles: Key technologies, network model, solutions, and challenges with future aspects," by Qureshi *et al.*, presents a comprehensive review and detailed background and motivation to evolve heterogeneous vehicular networks. The article also proposes new integrated models and key technologies related to network maintenance, a six-layered architecture model based on protocol stack and network elements, a network model based on cloud services, a big data analytical model based on data acquisition and analytics, and a security model based on detection and prevention systems. The article also envisions existing challenges and future directions to design new integrated models.

The article entitled "A knowledge-based temporal planning approach for urban traffic control," by Lu *et al.*, presents an approach based on automated planning, in particular a temporal planning scheme that aims to produce predictable UTC management strategies. Meanwhile, logic style control knowledge is employed to provide useful guidance for the search process in planning. They provide preliminary evaluations on simulation benchmarks closely related to UTC. Experimental results demonstrate the feasibility and effectiveness of their approach compared with state-of-the-art planners that participate in recent international planning competitions.

The article entitled "Mobility based trust evaluation for heterogeneous electric vehicles network in smart cities," by Wang *et al.*, introduces electric vehicles to conduct trust evaluations for heterogeneous vehicle networks in smart cities. Compared with traditional trust evaluation mechanisms, mobility-based trust evaluation has the advantages of low energy consumption and high evaluation accuracy. They also investigate the problem of minimizing transmission hops of trust evaluation and refer to this as the mobile trust evaluation problem (MTEP). They first formalize the MTEP into an optimization problem and present a heuristic moving strategy for a single electric vehicle. Then, they consider the MTEP with multiple electric vehicles. By scheduling the electric vehicles to access the nodes on the spanning tree with a maximum neighbor distance ratio, the algorithm can improve the efficiency of trust evaluation. In experiments, they compare the moving strategy of single electric vehicles and multiple electric vehicles with existing methods. The results demonstrate that the proposed algorithms can effectively reduce the entirety of transmission hops of trust evaluation and thus prolong the life of the network.

The article entitled "Model latent views with multi-center metric learning for vehicle re-identification," by Jin *et al.*, proposes a multicenter metric learning framework for multiview vehicle Re-ID. In their approach, they model latent views from vehicle visual appearance directly without needing any extra labels except ID. First, they introduce several latent view clusters for a vehicle to model latent multiview information, and each view cluster has a learnable center. Then, multiview vehicle matching tasks can be transformed into two subproblems: cross-view matching and cross-target matching. Finally, an intraclass ranking loss with a cross-view center constraint and a cross-class ranking loss with a cross-vehicle center constraint are proposed to address the two subproblems. The extensive experimental evaluations on three widely used benchmarks show the superiority of the proposed framework in contrast to a series of existing state-of-the-art methods.

The article entitled "Research on secure transmission performance of electric vehicles under Nakagami-m channel," by Ji *et al.*, studies the confidential transmission performance of an electric vehicle (EV) in a heterogeneous network when it communicates with a vehicle to grid (V2G) system. Based on a relay selection strategy that maximizes the signal-to-noise ratio (SNR), the electric vehicle, as a legitimate user in this article, uses a multiantenna maximum ratio combining method for signal reception. A single antenna is configured for the power grid sender, relay nodes, and illegal eavesdropping users. The wireless channel adopts the Nakagami-m fading channel, and the relay adopts the decode and forward (DF) method. First, based on the stochastic geometric analysis method, statistical characteristics such as the probability density function (PDF) and cumulative distribution function (CDF) of the received SNR are obtained for legitimate users and illegal eavesdropping users, respectively. Then, a functional analysis method is used to derive closed expressions for the secrecy outage probability (SOP) and nonzero security capacity probability in multiple eavesdropping user systems. Finally, the effects of the system's related parameters on the SOP and nonzero

security capacity probability are verified through simulations. The simulation results prove the correctness of the theoretical analysis, which can guarantee the privacy and security of electric vehicle users in a heterogeneous network.

The article entitled "Residual-network-leveraged vehicle-thrown-waste identification in real-time traffic surveillance videos," by Qian *et al.*, attempts to intelligently identify violations of throwing waste from vehicles (TWVs) in real-time traffic surveillance videos. In addition to polluting the environment, TWVs easily cause injury to sanitation workers responsible for cleaning roads by passing vehicles. However, manual inspection is still the most common way to recognize such uncivilized behavior in videos with very high time and labor consumption. To address these challenges, they design a novel 20-layer residual network (Nov-ResNet-20) for training the vehicle-thrown-waste identification model (VTWIM). Then, incorporating Nov-ResNet-20, a selective search, and non-maximum suppression (NMS), they propose the deep-residual-network-leveraged vehicle-thrown-waste identification method (DRN-VTWI). Their method first splits one video frame into several regions matching suspected objects marked with location boxes via a selective search. Then, in terms of the VTWIM trained by Nov-ResNet-20, their method identifies the regions containing TWVs. Last, their method removes the redundant location boxes for each recognized, vehicle-thrown waste and only keeps the best one. The experimental studies conducted on real-time traffic surveillance videos demonstrate the effectiveness and superiority of their efforts.

The article entitled "SDABS: A flexible and efficient multi-authority hybrid attribute-based signature scheme in edge environment," by Li *et al.*, proposes a multiauthority hybrid attribute-based signature scheme (SDABS). It is composed of four phases: system initialization, signature generation, signature verification, and attribute revocation phases. To better describe frequently changing features in transportation systems such as location, the dynamic attribute is introduced in building the signature. The multilayer policy tree is applied to support flexible and various access policies, which also naturally form user groups and assist in data searching. In addition, the multiauthority structure is more suitable for the distributed edge environment. They evaluate the SDABS in terms of both theoretical analysis and practical analysis. Compared with two classic signature schemes (MABS and ODMA-ABS), the experimental results demonstrate that the proposed SDABS can achieve better performance at an acceptable cost in terms of attributes and attribute authorities.

The article entitled "Trust-aware service offloading for video surveillance in edge computing enabled Internet of Vehicles," by Xu *et al.*, proposes a trust-aware task offloading method (TOM) for video surveillance in edge computing-enabled IoV for minimizing the response time of the services, achieving the load balance of the edge nodes and realizing privacy protection. Technically, SPEA2 (improving the strength Pareto evolutionary algorithm) is employed to acquire balanced task offloading solutions. Then, TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) and MCDM (Multiple Criteria Decision Making) are utilized to ascertain the optimal solution. Finally, an experimental simulation demonstrates that TOM performs efficiently and trustworthily.

In the article entitled "Vehicle assisted computing offloading for unmanned aerial vehicles in smart city," by Dai *et al.*, a vehicle-assisted computing offloading scheme for UAVs is proposed to improve offloading efficiency by harnessing moving vehicles in smart cities. First, an offloading model is developed for UAVs to determine the offloading strategy. Second, based on the preference lists of UAVs and vehicles, a matching scheme is developed to derive the optimal matching between UAVs and vehicles for offloading. Third, the transaction process for offloading between UAVs and vehicles is modeled as a bargaining game. Then, an offloading algorithm for UAVs and vehicles is proposed to obtain the optimal offloading strategy. Finally, simulations are performed to validate the efficiency of the proposed offloading scheme, which demonstrates that the proposed offloading scheme can significantly improve resource savings and the utilities of UAVs and vehicles.

The article entitled "When visual disparity generation meets semantic segmentation: A mutual encouragement approach," by Zhang *et al.*, proposes a Mutual Encouragement Network (MENet), which includes a semantic segmentation branch and a disparity regression branch and simultaneously generates a semantic map and visual disparity. In a cost volume construction phase, the depth information is embedded in the semantic segmentation branch to increase contextual understanding. Similarly, semantic information is also included in the disparity regression branch to generate a more accurate disparity. Two branches mutually promote each other during the training phase and the inference phase. They conduct their method on the popular data set KITTI, and the experimental results show that their method can outperform state-of-the-art methods on both visual disparity generation and semantic segmentation. In addition, extensive ablation studies also demonstrate that the two tasks in their method can facilitate each other significantly with the proposed approach.

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