Scanning the Issue

Driver Inattention Detection in the Context of Next-Generation Autonomous Vehicles Design: A Survey

A. El Khatib, C. Ou, and F. Karray

A survey of driver inattention detection systems is presented. The survey attempts to contextualize driver inattention detection systems within the frameworks of next-generation autonomous vehicles. To this end, the survey also explores the interaction between driver inattention detection systems and the increasing levels of vehicle automation and highlights the issues that arise at the intersection.

A Survey of Algorithms for Distributed Charging Control of Electric Vehicles in Smart Grid

N. I. Nimalsiri, C. P. Mediwaththe, E. L. Ratnam, M. Shaw, D. B. Smith, and S. K. Halgamuge

This article presents a survey covering the distributed charging control schemes that facilitate distributed computation of electric vehicle (EV) charge schedules. First, several designs of EV charging control architectures are identified as centralized, decentralized, and hierarchical systems, with the last two being referred to as distributed charging control systems. Next, the existing optimization problems related to EV charging control are categorized in terms of operational aspects and cost aspects and further subcategorized in the perspectives of the grid operator, the aggregator, and the EV user. Then, comprehensive discussions of distributed charging control schemes that belong to each subcategory are presented. Furthermore, different approaches to cope with various uncertainties inherent to EV charging control problems are discussed.

LMI-Based Synthesis of String-Stable Controller for Cooperative Adaptive Cruise Control

Y. Zhu, H. He, and D. Zhao

Controller synthesis is a challenging problem in cooperative adaptive cruise control (CACC). Especially, the requirement of string stability makes it even harder to choose appropriate control parameters. The authors apply a time-domain definition to string stability and convert the problem into the H-infinity control of a time-delay system. Based on the proposed control structure, the H-infinity norm and stability criteria of CACC are satisfied by a set of constraints in terms of a Lyapunov–Krasovskii functional candidate. These constraints are further reduced to linear matrix inequalities so that feasible solutions can be easily and efficiently computed. Simulations on an identified model validate the performance of their method in both frequency and time domains.

Optimal Petri-Net Controller for Avoiding Collisions in a Class of Automated Guided Vehicle Systems

J. Luo, Y. Wan, W. Wu, and Z. Li

For automated guided vehicle (AGV) systems with undistinguishable and uncontrollable events, an approach is presented to design a maximally permissive controller preventing AGVs from collisions. A labeled Petri net is utilized to model an AGV system, where labels represent sensor signals, and multiple transitions share the same label if there exist undistinguishable events. Furthermore, the control specification avoiding collisions between AGVs is formalized by linear constraints. An algorithm is obtained to compute the consistent markings given a sequence of labels, that is, the locations of AGVs given a sequence of sensor signals. With this algorithm, the controllable transitions, which should be disabled to prevent the Petri net from entering the markings violating linear constraints, are calculated for a current marking.

Ecological Adaptive Cruise Control With Optimal Lane Selection in Connected Vehicle Environments

S. Tajeddin, S. Ekhtiari, M. Faieghi, and N. L. Azad

Recent advances in transportation have enabled lane-specific measurements and controls. This article makes use of such data to promote the energy efficiency of vehicles. In particular, a multilane adaptive cruise controller (MLACC) is designed, which determines the optimal velocity and lane to drive in real time. This cruise controller solves the lane-specific optimization problems to compute an instantaneous trip cost for each lane and selects the lane with the lowest cost. The optimization tasks incorporate future route data and encompass multiple objectives, including safety, energy efficiency, and desired velocity tracking. Therefore, they can be treated as distinct nonlinear model predictive control (NMPC) problems that have to be solved altogether in each sampling time. To handle the computational load of solving multiple NMPCs in real time, the authors integrated Newton and generalized minimal residual numerical methods. The proposed MLACC is implemented for a 2013 Toyota Prius, and a wide range of simulation studies are performed to examine the controller. Specifically, hardware-in-the-loop experiments are utilized to evaluate the real-time implementability of the controller. In addition, extensive model-in-the-loop simulations are carried out and the results are compared with driver-in-the-loop experiments. The simulation results indicated that

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speed profiles and lane changes suggested by MLACC yield up to 27% improvement in energy consumption compared to human drivers.

BRT: Bus-Based Routing Technique in Urban Vehicular Networks

N. Chaib, O. S. Oubbati, M. L. Bensaad, A. Lakas, P. Lorenz, and A. Jamalipour

Routing data in vehicular ad hoc networks is still a challenging topic. The unpredictable mobility of nodes renders routing of data packets over optimal paths not always possible. Therefore, there is a need to enhance the routing service. *Bus Rapid Transit* systems, consisting of buses characterized by a regular mobility pattern, can be a good candidate for building a backbone to tackle the problem of uncontrolled mobility of nodes and to select appropriate routing paths for data delivery. For this purpose, the authors propose a new routing scheme called bus-based routing technique (BRT) that exploits the periodic and predictable movement of buses to learn the required time (the temporal distance) for each data transmission to roadside units (RSUs) through a dedicated bus-based backbone. Indeed, BRT comprises two phases: 1) learning process that should be carried out, basically, one time to allow buses to build routing table entries and expect the delay for routing data packets over buses and 2) data delivery process that exploits the pre-learned temporal distances to route data packets through the bus backbone toward an RSU (backbone mode). BRT uses other types of vehicles to boost the routing of data packets and also provides a maintenance procedure to deal with unexpected situations such as a missing next-hop bus, which allows BRT to continue routing data packets. The simulation results show that BRT provides good performance results in terms of delivery ratio and end-to-end delay.

Cooperative Driving at Unsignalized Intersections Using Tree Search

H. Xu, Y. Zhang, L. Li, and W. Li

In this article, the authors propose a new cooperative driving strategy for connected and automated vehicles (CAVs) at unsignalized intersections. Based on the tree representation of the solution space for the passing order, they combine Monte Carlo tree search (MCTS) and some heuristic rules to find a nearly global-optimal passing order (leaf node) within a very short planning time. Testing results show that this new strategy can keep a good tradeoff between performance and computation flexibility.

A Real-Time ATC Safety Monitoring Framework Using a Deep Learning Approach

Y. Lin, L. Deng, Z. Chen, X. Wu, J. Zhang, and B. Yang

A deep learning-based safety monitoring framework is proposed to detect operational safety risks in air traffic control systems. The controlling speech between pilots and controllers is introduced to improve the timeliness and reliability of real-time information, which further improves the traffic prediction performance. The framework is summarized as follows: an end-to-end deep learning-based automatic speech recognition (ASR) model is proposed to translate the controlling speech into text. The language understanding (LU) technique with deep neural network is further proposed to extract the air traffic-related elements. Three types of air traffic safety measures, including repetition check, flight conformance verification, and potential conflict detection, are finally validated based on the ASR and LU results. To the best of the authors' knowledge, this is the first work in the safety monitoring of flight control by recognizing the controlling speech with deep learning-based methods.

Robust Network-Wide Bus Scheduling With Transfer Synchronizations

K. Gkiotsalitis, O. A. L. Eikenbroek, and O. Cats

Travel time and demand disturbances lead to unreliable bus operations and missed passenger transfers. This study formulates the multiline synchronization problem as a robust minimax problem that considers the fluctuations of the travel and dwell times of bus trips. Given the infeasibility of the multiline synchronization problem in extreme cases of travel/dwell time disturbances, the authors introduce a flexible problem formulation that incorporates the constraint violations into the objective function. To produce a robust schedule, the dispatching times of trips are their design variables and the travel and dwell time fluctuations are the environmental variables that have an adversarial role in the minimax problem. They validate their approach in the bus network of The Hague using actual vehicle location and passenger counting data for a month. There, they demonstrate the potential improvement in terms of service regularity and increased synchronizations in the common case and extreme case conditions.

CircleNet: Reciprocating Feature Adaptation for Robust Pedestrian Detection

T. Zhang, Z. Han, H. Xu, B. Zhang, and Q. Ye

Pedestrian detection in the wild remains a challenging problem. In this article, the authors propose a novel feature learning model, called CircleNet, to achieve feature adaptation by mimicking the process humans looking at low resolution and occluded objects: focusing on it again, at a finer scale, if the object cannot be identified clearly for the first time. CircleNet is implemented as a set of feature pyramids and uses weight-sharing path augmentation for better feature fusion. It targets at reciprocating feature adaptation and iterative object detection using multiple top-down and bottom-up pathways. To take full advantage of the feature adaptation capability in CircleNet, they design an instance decomposition training strategy to focus on detecting pedestrian instances of various resolutions and different occlusion levels in each cycle. Specifically, CircleNet implements feature ensemble with the idea of hard negative boosting in an end-to-end manner.

Cooperative Lane Changing Strategies to Improve Traffic Operation and Safety Nearby Freeway Off-Ramps in a Connected and Automated Vehicles Environment

Y. Zheng, B. Ran, X. Qu, J. Zhang, and Y. Lin

A cooperative lane-changing strategy is proposed to improve traffic operation and safety at a diverging area nearby a highway off-ramp in an environment with connected and automated vehicles (CAVs). The cooperative strategy was implemented by the coordination of behaviors between the diverging vehicle and its cooperative vehicle on the target lane. The experimental results showed that the cooperative strategy with the optimal zones could improve traffic operation, traffic safety, and traffic oscillation compared to the modified MOBIL strategy with the fixed zone. The cooperative strategy can be potentially implemented nearby highway off-ramps by vehicle-based control, with the applications of the aforementioned cooperative zones.

Interactive Trajectory Prediction of Surrounding Road Users for Autonomous Driving Using Structural-LSTM Network

L. Hou, L. Xin, S. E. Li, B. Cheng, and W. Wang

Accurate trajectory prediction of surrounding road users is critical to autonomous driving systems. In mixed traffic flows, road users with different kinds of behaviors and styles bring complexity to the environment, which requires considering interaction among road users when anticipating their future trajectories. This article presents a long-term interactive trajectory prediction method for surrounding vehicles using a hierarchical multisequence learning network. In contrast to noninteractive method, which assumes that road users are independent of each other, this method can automatically learn high-level dependencies among multiple interacting vehicles through the proposed structural long short-term memory (LSTM) network. Specifically, structural LSTM first assigns multiple LSTMs for each interacting vehicle, which shares their cell states and hidden states with their spatial-neighboring LSTMs by a radial connection and then recurrently analyze the output state of itself as well as the other LSTMs in a deeper layer, based on whose output to predict trajectories for the target vehicle. The proposed method is evaluated on the NGSIM data set, and its results show that satisfying accurate prediction performance of surrounding vehicle long-term trajectories is accessible, for example, longitudinal and lateral RMS errors can be reduced to less than 1.93 and 0.31 m over the 5-s time horizon, respectively.

Temporally Consistent Depth Prediction With Flow-Guided Memory Units

C. Eom, H. Park, and B. Ham

Predicting depth from a monocular video has advanced considerably in the past few years. However, recent methods estimate depth independent of each frame, discarding temporal cues, which often leads to temporally inconsistent results. To address this, the authors propose to memorize temporal consistency in the video sequence and leverage it for the task of depth prediction. To this end, they introduce a two-stream CNN with a flow-guided memory module, where each stream encodes visual and temporal features. The memory module, implemented using convolutional gated recurrent units (ConvGRUs), inputs visual and temporal features sequentially together with optical flow tailored to their task. It memorizes trajectories of individual features selectively and propagates spatial information over time, enforcing a long-term temporal consistency to prediction results. They evaluate their method on the KITTI benchmark data set in terms of depth prediction accuracy, temporal consistency, and runtime and achieve a new state of the art.

Efficient Collection of Connected Vehicles Data With Precision Guarantees

N. Alemazkoor and H. Meidani

Connected vehicles disseminate detailed data, including their position and speed, at a very high frequency. Such data can be used for accurate real-time analysis, prediction, and control of transportation systems. The outstanding challenge for such analysis is how to continuously collect and process extremely large volumes of data. To address this challenge, efficient collection of data is critical to prevent overburdening the communication systems and overreaching computational and memory capacity. In this work, the authors propose an efficient data collection scheme that selects and transmits only a small subset of data to alleviate data transmission burden. As a demonstration, they have used the proposed approach to select data points to be transmitted from 10 000 connected vehicle trips available in the Safety Pilot Model Deployment data set. The presented results show that the collection ratio can be as small as 0.05 depending on the required precision. Moreover, a simulation study was performed to evaluate the travel time estimation accuracy using the proposed data collection approach. The results show that the proposed data collection approach can significantly improve travel time estimation accuracy.

Persistent Stereo Visual Localization on Cross-Modal Invariant Map

X. Ding, Y. Wang, R. Xiong, D. Li, L. Tang, H. Yin, and L. Zhao

In this article, the authors focus on dealing with priori laser map-based long-term stereo visual localization in the outdoor environment. To achieve this goal, the cross-modal invariance is investigated to modify the laser map. Specifically, a map learning algorithm is introduced to remove the vision-uncorrelated and dynamic data in laser maps using multi-session visual and laser data and a generative map model is derived to describe the cross-modal invariance. Based on this map model, two types of visual measurements are derived to align the laser map and visual observations. By including these measurements into local bundle adjustment in the sliding window-based visual odometry, a tightly coupled localization framework is proposed where the precise geometry of the laser map is utilized to promote the optimization process, leading to better estimation of the trajectory against the map.

Modeling Arterial Traffic Dynamics With Actuated Signal Control Using a Simplified Shockwave Model

X. Wu, G. Wang, D. Fu, T. K. Tong, Z. Zhang, and W. Li

Currently, most of the macroscopic models are incapable of adequately reproducing the stochastic nature of traffic dynamics because of the randomness of vehicle speed. To solve this problem, this research proposed an innovative model that incorporates a simplified shockwave model with traffic diffusion theory, which is able to reproduce the stochastic nature of traffic dynamics. The simulation results and comparison with field=observed data verify that the proposed model is not only to model the traffic dynamics on arterials but also able to derive signal timings of actuated intersections. Such results are inspiring as this model can be applied to a variety of real-time applications, such as arterial traffic flow estimation, performance prediction, and signal optimization.

DLT-Net: Joint Detection of Drivable Areas, Lane Lines, and Traffic Objects

Y. Qian, J. M. Dolan, and M. Yang

A unified neural network named DLT-Net is proposed to detect drivable areas, lane lines, and traffic objects simultaneously. These three tasks are most important for autonomous driving, especially when a high-definition map and accurate localization are unavailable. Instead of separating tasks in the decoder, context tensors between sub-task decoders are constructed to share designated influence among tasks. Therefore, each task can benefit from others during multitask learning.

Headway Control in Bus Transit Corridors Served by Multiple Lines

L. O. Seman, L. A. Koehler, E. Camponogara, L. Zimmermann, and W. Kraus, Jr.

This article analyzes the problem of optimizing the operation of bus rapid transit (BRT) lines that share a common corridor. The goal is to minimize passengers' travel time, including waiting time at stations. In the common corridor, stations are shared by several bus lines, which presents riding alternatives for passengers with origins and destinations within the corridor. Since buses from different lines interact in the corridor, optimal multiline headways that consider headways across all lines can alter single-line headways so as to maximize the user benefit. The method implements the required bus headway regulation for multiple lines in an integrated and simultaneous manner. Numerical tests of the optimization approach developed for the system model show the distinctive features of the solutions, indicating the superiority of multiline headway control over its single-line counterpart.

Intelligent Hazard-Risk Prediction Model for Train Control Systems

J. Liu, Y. Zhang, J. Han, J. He, J. Sun, and T. Zhou

Although there has been substantial research in system analytics for risk assessment in traditional methods, little work has been done for safety risk prediction in the communication-based train control (CBTC) system, especially intelligently predicting risk caused by the uncertainty in the system operation. In this article, the authors propose an intelligent hazard-risk prediction model based on a deep recurrent neural network for a new communication-mode CBTC system. First, a train-to-train communication-based train control (T2T-CBTC) system is proposed to improve the drawback of CBTC in the information-exchanging mode. Then, they design a risk prediction feature selection and generation method and estimate a critical function feature in the T2T-CBTC system by statistical model checking. Finally, they construct their intelligent hazard-risk prediction model based on a deep recurrent neural network using a long short-term memory (LSTM) network. The model had excellent risk prediction classification results and performance in their experiment, even for unbalanced data set.

Vehicular Named Data Networking Framework

X. Wang and Y. Li

This article proposes a novel vehicular framework called dated networking framework and aims to reduce data retrieval latency and costs and improve data acquisition success rates. In this framework, a cluster-chain vehicular backbone is constructed to enhance network stability. Based on cluster chains, consumers can employ request aggregation and unicast to acquire data from the nearest provider. Moreover, consumer mobility is supported to guarantee successful retrieval of data despite the high mobility of vehicles. This framework is quantitatively evaluated. According to the experimental results, compared with the existing approaches, their framework reduces the data acquisition cost and delay by nearly 54.6% and 12.3%, respectively, and improves the data retrieval success rate by nearly 7.9%.

The Viscosity Solution for Hamilton Jacobi Travel Time Dynamics

S. Contreras and P. Kachroo

Travel time is an important concept in various intelligent transportation system applications. A density-based travel time partial differential equation (PDE) based on the Lighthill–Whitham–Richards (LWR) model and its dynamics are reviewed. The travel time dynamics are an asymmetric, one-sided coupled system of hyperbolic PDEs. Although the model has been derived previously and its applications have been proposed, important properties of the solution to the travel time PDE are studied for the first time. The travel time PDE has the form of a Hamilton–Jacobi equation. For this type of equation, finding a unique solution that is consistent with reality is accomplished by finding its viscosity solution. The main contribution of this article is the mathematical development of the method for finding the viscosity solution of the given travel time PDE.

Joint Fleet Sizing and Charging System Planning for Autonomous Electric Vehicles

H. Zhang, C. J. R. Sheppard, T. E. Lipman, and S. J. Moura

A mixed-integer linear programming model for joint autonomous electric vehicle (AEV) fleet sizing and charging system planning in intercity scenarios is proposed. This model incorporates comprehensive considerations of: 1) limited driving range; 2) optimal routing and relocating operation; 3) time-varying origin–destination transport demands; and 4) differentiated operation cost structure of passenger and goods transportation. The experimental results show that AEVs in passenger and goods transportation have remarkable planning and operation differences. Intelligent routing and relocating operations, charging system, and vehicle parameters, for example, charging power, battery capacity, and driving speed, can significantly affect the economic efficiency and the planning results of an AEV fleet.

Communication Latency and Speed-Dependent Minimum Time Headway for Connected Heavy Road Vehicle Collision Avoidance

V. R. S. Yellapantula, K. B. Devika, and S. C. Subramanian

Collision avoidance systems can help reducing fatalities through automated braking when required. This article focuses on the development of a framework for computing the minimum time headway for a vehicle-to-vehicle (V2V) communication-based collision avoidance system for heavy commercial road vehicles (HCRVs). The framework, as well as the developed collision avoidance algorithm (CAA), considers the critical attributes of an HCRV, such as significant static and dynamic load variations and brake actuator dynamics. Furthermore, this time headway formulation explicitly considers the vehicle's initial longitudinal speed and the communication latency. Experiments were conducted in a hardware-in-loop test setup, and it was found that the proposed formulation avoided collisions under a wide range of operating conditions while satisfying the desired final spacing requirement. However, a formulation that did not consider communication latency could not satisfy the desired final spacing requirement.

A Multi-Objective Emergency Rescue Facilities Location Model for Catastrophic Interlocking Chemical Accidents in Chemical Parks

J. Men, P. Jiang, S. Zheng, Y. Kong, Y. Zhao, G. Sheng, N. Su, and S. Zheng

A novel multiobjective emergency rescue facilities location model is proposed for emergency management of catastrophic interlocking chemical accidents (CICAs) in chemical parks. To delineate the negative impacts of CICAs on different demand points, a quantitative area risk assessment approach based on the domino effect and grid partition is incorporated into the construction of the location model. With a matrix encoding scheme designed, three multiobjective evolutionary algorithms (MOEAs) are adopted for model solving. Experimental results indicate that the matrix encoding scheme and the corresponding evolutionary operators can be successfully coupled with the MOEAs to produce feasible child solutions. The proposed method is able to provide a set of reasonable and nondominated solutions and has the potential to ensure the safety and long-term development of the chemical parks.

3D Highway Curve Reconstruction From Mobile Laser Scanning Point Clouds

Z. Zhang, J. Li, Y. Guo, C. Yang, and C. Wang

A two-step approach is proposed for automated detection and reconstruction of three-dimensional (3-D) highway curves from mobile laser scanning (MLS) point clouds. The approach is formed by two main algorithms: a detector based on intensity variance and a robust model fitting estimator. The experimental results obtained using both a virtual scan data set and a real MLS data set demonstrated that the proposed approach is very promising in handling the outliers and reconstruction of 3-D road curves. Specifically, a relative accuracy of 0.6% has been achieved in the estimation of radii of the circles based on the virtual scan data set. A comparative study also showed that the proposed road marking detection algorithm is more effective and more stable than state-of-the-art approaches.

Intention Recognition of Pedestrians and Cyclists by 2D Pose Estimation

Z. Fang and A. M. López

Anticipating the intentions of vulnerable road users (VRUs), such as pedestrians and cyclists, is critical for performing safe and comfortable autonomous driving. In this article, the authors show how CNN-based, monocular vision-based human pose estimation enables the recognition of the intentions of such VRUs. In the case of cyclists, they assume that they indicate future maneuvers with arm signals. In the case of pedestrians, no indications can be assumed. Instead, they hypothesize that the walking pattern of pedestrians allows them to determine whether they have the intention of crossing the road in the path of the ego vehicle. They show how the same methodology can be used for recognizing pedestrians and cyclists' intentions. For pedestrians, they perform experiments on the JAAD data set. For cyclists, they did not find an analogous data set, and thus, they created one by acquiring and annotating videos that they share with the research community.

An Efficient Ant Colony System Approach for New Energy Vehicle Dispatch Problem

D. Liang, Z.-H. Zhan, Y. Zhang, and J. Zhang

With the popularization of new energy vehicle (NEV), its unique dispatch research is imminent. This article studies the online order allocation task for NEV and establishes an NEV dispatch model, which considers traffic factors such as the electricity of vehicles and charging piles. Two-level measurement of customer satisfaction is designed, which combines the acceptance rate of service requests and customer waiting time. An efficient ant colony system (EACS) approach enhanced by the pre-selection strategy and local pruning strategy is designed to dispatch NEVs to passengers. Experiments are carried out to investigate the applicable scenarios of ACS-based algorithms. The results verify that the proposed EACS algorithm can provide global high-quality allocation solutions in a short time.

Attention-Based Deep Ensemble Net for Large-Scale Online Taxi-Hailing Demand Prediction

Y. Liu, Z. Liu, C. Lyu, and J. Ye

How to effectively ensemble different base models is a challenging but extremely valuable task. This study focuses on the construction of an ensemble framework designed for spatio-temporal data to predict large-scale online taxi-hailing demand, where an attention-based deep ensemble net is designed to enhance the prediction accuracy. The authors present three attention blocks to model the inter-channel relationship, inter-spatial relationship, and position relationship of the feature maps. The experimental results on city-wide online taxi-hailing demand predictions demonstrate that their proposed attention-based ensemble net is superior to the existing ensemble strategy in terms of the prediction accuracy.

Extended Look-Ahead Tracking Controller With Orientation-Error Observer for Vehicle Platooning

A. Bayuwindra, E. Lefeber, J. Ploeg, and H. Nijmeijer

This article presents a novel extended look-ahead concept of an integrated lateral and longitudinal vehicle following controller with an orientation-error observer. The control law is based on the input–output feedback to address a local tracking problem. It is known that due to the position control in the look-ahead approach, the follower vehicle may cut corners. To address this problem, a reference-induced extended look-ahead tracking point is introduced such that the cutting corner is compensated. Moreover, the stability of the internal dynamics is analyzed. To address the situation where the orientation tracking error is not measurable or corrupted by noise, an orientation-error observer, constructed from the position tracking error, is designed. The performance of the extended look-ahead controller and the orientation-error observer is investigated using a simulation study and validated with experiments on a mobile robot platform.

Operating Electric Vehicle Fleet for Ride-Hailing Services With Reinforcement Learning

J. Shi, Y. Gao, W. Wang, N. Yu, and P. A. Ioannou

This article develops a reinforcement learning (RL)-based algorithm to dispatch an electric vehicle (EV) fleet for ride-hailing services. The proposed RL-based algorithm is built on a novel framework with decentralized learning and centralized decision-making. The decentralized learning allows the entire EV fleet to share their experiences and parameters of the approximated state-value function, which greatly improves the algorithm's scalability. The centralized decision-making process enables the coordination of the individual EVs by formulating the EV fleet dispatch problem as an assignment problem, which maximizes the EV fleet's action-value function. A comprehensive numerical study is carried out to evaluate the performance of the proposed framework. The simulation results show that their proposed RL algorithm outperforms the benchmark algorithms in terms of EV operational costs and the customer waiting time.

Approximation Algorithms for Road Coverage Using Wireless Sensor Networks for Moving Objects Monitoring

D. Dash

This article introduces a new partial coverage metric for road networks for moving object monitoring. The sensors' deployment scheme to achieve partial road coverage using the minimum number of sensors is proved as an NP-hard problem. Geometry-based approximation algorithms are proposed. The proposed methods find the positions of the sensors for two special cases: arbitrary sensor placement and side boundary sensor placement. The simulation results show that the proposed algorithms perform much better than their proved upper bounds.

Robust Revocable Anonymous Authentication for Vehicle to Grid Communications

V. T. Kilari, R. Yu, S. Misra, and G. Xue

This article presents a robust revocable anonymous authentication framework for vehicle-to-grid communications. It finds applications in charging of electric vehicles, where both the charging station and the electric vehicles are protected. The mechanism is permit-based, where each vehicle is only issued with one blind signature-based permit at a time. The identity of the vehicle is protected unless it misbehaves, in which case the identity of the malicious vehicle can be identified. Security analysis and experiments demonstrate that the proposed framework, while ensuring user anonymity and being robust to various attack, is also scalable and lightweight.

A Unified Lateral Preview Driver Model for Road Vehicles

S. Zhu and Y. He

This article presents a unified lateral preview driver model for closed-loop dynamic simulations of road vehicles. Numerous driver models have been proposed for single-unit vehicles (SUVs). Some SUV-based driver models have been applied to closed-loop simulations of multitrailer articulated heavy vehicles (MTAHVs). However, the dynamics of MTAHVs is significantly different from that of SUVs, and drivers of multi-unit vehicles (MUVs) have different driving performance and skills. A very few driver models have been proposed for closed-loop simulations of MUVs. This article designs the unified driver model, considering the dynamic features of both SUVs and MUVs. The driver model is derived using a sliding mode control (SMC) technique, and it distinguishes itself from conventional driver models with a number of features. Simulations demonstrate the applicability and effectiveness of the proposed driver model.

Error Correction CP-BZD Storage Codes for Content Delivery in Drive-Thru Internet

M. Dai, S. Lu, N. Zhang, X. Li, and H. Wang

For CP-BZD structured distributed storage systems, without adding extra checking bits (error-correcting code), a novel decoding method that reaps error correction ability is proposed. Complexity analysis of this proposed method is performed, and a low-complexity algorithm is designed. This method has self-error correction capability and is completely optional, adaptable, and flexible to be deployed to various environments.

Traffic Graph Convolutional Recurrent Neural Network: A Deep Learning Framework for Network-Scale Traffic Learning and Forecasting

Z. Cui, K. Henrickson, R. Ke, and Y. Wang

Network-wide traffic forecasting is challenging, due to the time-varying traffic patterns and the complicated spatial dependencies on road networks. To address this challenge, this study learns the traffic network as a graph and propose a novel deep learning framework, traffic graph convolutional long short-term memory neural network (TGC-LSTM), to learn the interactions between roadways in the traffic network and forecast the network-wide traffic state. The traffic graph convolution is based on the physical network topology. The experimental results show that the proposed model outperforms the baseline methods on two real-world traffic state data sets. The visualization of the graph convolution weights also indicates that the proposed framework can recognize the most influential road segments in real-world traffic networks.

Ecological Adaptive Cruise Control for Vehicles With Step-Gear Transmission Based on Reinforcement Learning

G. Li and D. Görges

In this article, an ecological adaptive cruise controller to reduce the fuel consumption and ensure the safe inter-vehicle distance for vehicles with step-gear transmissions is presented. An optimal control strategy using reinforcement learning with a novel actor–gear–critic architecture is proposed to obtain the continuous traction force trajectory and the discrete gear shift schedule. The traction force is determined from an actor network to maintain a desired inter-vehicle distance. The gear shift schedule is derived from a gear network to reduce fuel consumption. The control strategy is model-free and allows continuous online learning for different driving situations without look-ahead velocity information. In particular, the nonlinear vehicle dynamics, the nonlinear transmission efficiency map for different gear ratios, and the nonlinear fuel consumption map are learned for fuel consumption reduction. Simulation comparisons for different gear shift schedules and velocity trajectories are given, underlining the advantages in terms of fuel economy and driving safety.

Road Damage Detection Based on Unsupervised Disparity Map Segmentation

R. Fan and M. Liu

This article presents a novel road damage detection algorithm based on unsupervised disparity map segmentation. First, the disparity map is transformed by minimizing an energy function with respect to stereo rig roll angle and road disparity projection model. Instead of minimizing the energy function using nonlinear optimization techniques, the authors directly find its numerical solution. The transformed disparity map is then segmented using Otus's thresholding method to extract damaged road areas. The proposed algorithm requires no parameters when detecting road damage. The experimental results illustrate that their proposed algorithm performs accurately and efficiently. The pixel-level accuracy and F-score are 99.63% and 86.17%, respectively.

On the Use of Glint-Doppler-Azimuth Correlation for Speed Estimation of Nearby Tangential Targets

A. Asensio López, J. Muñoz Dekamp, Á. Duque de Quevedo, F. Ibañez Urzaiz, and J. Gismero Menoyo

The Glint effect consists in an important radar cross section (RCS) fluctuation due to the targets' multiscatterer nature. This particularly affects low-range radar systems, for example, radar-based traffic flow control systems, which usually suffer a rise in the azimuth-and-Doppler estimation error when a target approaches the sensor. Nevertheless, there is a linear relationship between these two magnitudes, azimuth and Doppler shift; thus, the Glint effect affects both magnitudes simultaneously, and this correlation can be exploited by a radar to improve its speed estimation accuracy, if the system is able to measure both magnitudes concurrently. This is the case of the proposed radar architecture, which opts for a two-channel digital array receiver scheme working with a frequency-modulated continuous wave. With an easy-and-fast side-looking installation, designed for traffic flow applications, it implements a novel signal processing scheme that exploits the cited correlation, achieving a considerable speed estimation improvement.

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