Scanning the Issue

A Study of the Effectiveness of Message Content, Length, and Rate Control for Improving Map Accuracy in Automated Driving Systems

S M O. Gani, Y. P. Fallah, G. Bansal, and T. Shimizu

The effectiveness of content-adaptive scalable communication architecture in automated driving systems is studied in this paper. More specifically, this paper examines how vehicle tracking capability in such systems can further be improved by making optimal use of the communication channel through sharing of locally created map (using on-board sensors such as LIDAR, radar, camera, and GPS) data instead of transmitting only periodic beacon messages. Different approaches toward DSRC channel congestion control is investigated considering associated tradeoffs. Various distance-based content adaptation schemes are examined in terms of position tracking capability. This paper determines that message content should be concentrated on mapped objects that are located farther away from the sender, but near the edge of local sensor range. This paper also finds that optimized combination of message length and transmit rate ensures the optimal channel utilization for cooperative vehicular communication, which in turn improves the situational awareness of the whole system.

Driver Sleepiness Classification Based on Physiological Data and Driving Performance From Real Road Driving

H. Mårtensson, O. Keelan, and C. Ahlström

This paper proposes a research tool to classify driver sleepiness based on physiological data and driving performance data. The classifier was trained on what the authors believe is the largest labeled real road driver sleepiness database in the world. The most suitable classifier, a random forest classifier, reached an accuracy of 94.1%. The results further showed the usefulness of incorporating a biomathematical sleepiness model amongst the features and also the importance of personalized sleepiness detection systems. When testing the classifier on data from a person that it had not been trained on, the sensitivity dropped to 41.4% (or 66.2% when making use of a biomathematical model in the system).

Development of Dynamic Platoon Dispersion Models for Predictive Traffic Signal Control

L. Shen, R. Liu, Z. Yao, W. Wu, and H. Yang

This paper focuses on investigating dynamic platoon dispersion models which could capture the variability of traffic flow in a cross-sectional traffic detection environment. Then, the authors investigate factors affecting model accuracy, including time-zone length, position of upstream traffic detection equipment, road section length, traffic volume, turning percentages, and computation time. The results show that both the dynamic speed-truncated normal distribution model and dynamic Robertson model with dynamics outperform their respective static versions, and that they can be further applied for dynamic control.

Development and Validation of a Distance Measurement System in Metro Lines

H. Song and E. Schnieder

In this paper, a formal approach is presented for the development and verification of a new metro train-to-train distance measurement system. This system is based on the spread-spectrum technology to accomplish distance measurement. Different from existing systems in the air and maritime transport, this system does not require any other localization unit, except for a communication unit. To assist the development of the system, colored Petri nets are used to formalize and evaluate its structure. In addition, a procedure is proposed to generate a code architecture from the formal model. The system performance is assessed in terms of the range and accuracy of its detection. The results indicate that the system is able to carry out distance measurement in metro lines, and the formal approaches are reusable for further development and verification of other systems.

Emergency Steering Evasion Assistance Control Based on Driving Behavior Analysis

Z. Zhao, L. Zhou, Y. Luo, and K. Li

A CarSim vehicle model integrated driving simulator is built to acquire and analyze the driving behaviors in emergency steering evasion (ESE). Based on the analysis of driving behaviors, an ESE controller is proposed for a driver-controlled hybrid vehicle so that the electric stability program (ESP) and the hub motors can utilize the remaining tire force to generate an additional yaw moment. The controller provides a driver model with the adaptive preview distance and optimizes the path tracking accuracy, steering frequency, and vehicle stability. The test results show that the path tracking accuracy and the vehicle stability are simultaneously improved in different driving behaviors.

Variable Step-Size Discrete Dynamic Programming for Vehicle Speed Trajectory Optimization

Z. Ye, K. Li, M. Stapelbroek, R. Savelsberg, M. Günther, and S. Pischinger

A novel approach of applying discrete dynamic programming with variable step-size in stage variable discretization is proposed to optimize vehicle speed trajectory. In this approach, a “meshing” algorithm searches the points of interest (POI),

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such as speed limit change, traffic lights, and road curvatures, where changes in vehicle speed are expected. The algorithm increases the step-size resolution close to these points and reduces the resolutions in positions further away from the POI, where the optimized vehicle speed is insensitive to the step-size. In a test case with a relatively high density of POI, the computational cost is reduced by more than 53% by only sacrificing less than 1% of precision compared to a fixed step-size discretization with high resolutions.

Efficient Real-Time Control Design for Automatic Train Regulation of Metro Loop Lines

S. Li, L. Yang, and Z. Gao

The efficient real-time control is designed for automatic train regulation of metro loop lines subjected to frequent minor disruptions. Under the frequent minor disruptions, a dynamic optimal control model is developed to determine the automatic train regulation strategy to improve punctuality and regularity of the metro operation with the safety and control constraints. To solve the formulated optimal control model with the updated information, a real time control algorithm based on a model predictive control approach is designed, which splits the original optimization problem into a set of convex quadratic programing problems, which can be numerically calculated efficiently and satisfy the real-time control requirement.

Real-Time Traffic Prediction and Probing Strategy for Lagrangian Traffic Data

K.-C. Chu, R. Saigal, and K. Saitou

A new analytical tool utilizing the stochastic Lagrangian traffic flow model and unscented Kalman filter is developed to predict highway congestion in real time. Also, an adaptive data collection strategy that adjusts the number of probing vehicles based on the variance of the prediction from the stochastic model is investigated. Empirical highway traffic data are used to show that the proposed stochastic model provides more accurate traffic status prediction compared with a deterministic Lagrangian model. The estimated parameter in the model can capture the transition into traffic jam and provide warnings to drivers in advance. The results from adaptive probing suggest that it can efficiently use less data to provide higher prediction accuracy than non-adaptive probing.

Distributed Mean-Field-Type Filters for Traffic Networks

J. Gao and H. Tembine

Traffic surveillance plays an important role in the development of the smart cities and urban systems. In this paper, the authors proposed a new kind of distributed mean-field-type filter to solve the filtering problem in large-scale traffic networks. To deal with noisy and high-dimensional observed data, the filter incorporates a mean-field term into the system model and decomposes the state space into highly independent parts; filtering is performed in each part and then integrated. To achieve accurate estimations, the procedure iterates over four steps: prediction, sampling, decomposition, and correction. Theoretical analysis suggests the global error has a linear bound, which is independent of the network's cardinality. The proposed approach has been tested in aircraft and vehicle tracking scenarios. Observations were obtained by radar sensors and traffic cameras. Both simulations and real experiments demonstrate the advantage of the filter over traditional mean-field-free filters.

Predict Vehicle Collision by TTC From Motion Using a Single Video Camera

M. Kilicarslan and J. Y. Zheng

An instantaneous computation of time-to-collision for potential collision system is proposed. The level of collision event is directly computed from motion divergence in driving videos. Both vertical and horizontal motion features are analyzed in several collision sensitive zones in real time. The results show the effectiveness of the proposed method using motion profiles.

Automatic Identification System-Based Approach for Assessing the Near-Miss Collision Risk Dynamics of Ships in Ports

Z. Fang, H. Yu, R. Ke, S.-L. Shaw, and G. Peng

Automatic identification system-based approach is proposed for adaptively calibrating near-miss collision risk model and assessing a ship's near-miss collision risk by using the vessel's speed and course patterns to obtain a robust estimate of the collision risk. Six measures are employed to determine the hierarchical geographical distribution of the near-miss collision risk for ships in port areas and to identify the high-risk areas. Some predicted high-risk areas were validated as official precautionary areas in the Xiamen Port area. All predicted areas may help the port administration to plan monitoring areas to ensure safe traffic flow in the port.

Inferring Pedestrian Motions at Urban Crosswalks

B. Völz, H. Mielenz, I. Gilitschenski, R. Siegwart, and J. Nieto

For urban automated driving, a robust prediction of pedestrian behaviors around urban roads is of considerable importance. This paper presents an approach for predicting pedestrian motions that combines established motion tracking algorithms with data-driven methods. It is built upon a hierarchical structure, where, first the intent of each pedestrian is classified. Then, several qualitative metrics, that describe where and when a pedestrian will cross the road, are computed. The approach is evaluated on a challenging urban data set collected for different types of crosswalks such as roundabouts and straight roads. The evaluation also provides a thorough analysis of the generalization performance of the proposed approach.

Modeling Probabilistic Flooding in VANETs for Optimal Rebroadcast Probabilities

T. Saeed, Y. Mylonas, A. Pitsillides, V. Papadopoulou, and M. Lestas

This paper deals with the design of effective probabilistic flooding schemes for vehicular ad hoc networks, based on generic mathematical models which can cover any number of lanes, vehicle transmission range, and density. The models are validated using simulations, realistically representing both the traffic and networking aspects, and are used as a baseline to design two schemes for information dissemination which employ probabilistic flooding. The one attempts direct calculation of the required parameters whereas the other adaptively regulates the rebroadcast probability based on the vehicle speed. The schemes are evaluated using simulations and are found to achieve significant performance improvements compared to blind flooding with respect to the achieved reachability, end-to-end delay, and number of rebroadcasts, and is comparable to the performance achieved by optimal flooding, obtained via brute force.

Taxi Drivers' Cruising Patterns—Insights From Taxi GPS Traces

F. Zong, T. Wu, and H. Jia

This paper identifies the impacts of external factors (land use, traffic conditions, and road grade) and internal factors (previous pick-up experience) on taxis' cruising location choice using a zero-inflated negative binomial model. The results indicate that the external factors have a more significant influence than the internal ones. The results also show that drivers follow different patterns during different times of the day, i.e., relying on traffic conditions and land use in the morning/evening peak hours but emphasizing land use and previous pick-up experience during non-peak hours. In addition, high-earning drivers and roaming drivers prefer to cruise in areas with high-density land use and optimal traffic conditions, whereas low-earning drivers and target drivers tend to cruise in areas with more previous pick-up points. The findings uncover the underlying mechanisms of cruising decisions and facilitate the development of strategies to minimize empty cruising time.

Discovery of Critical Nodes in Road Networks Through Mining From Vehicle Trajectories

M. Xu, J. Wu, M. Liu, Y. Xiao, H. Wang, and D. Hu

This paper proposes two novel algorithms to identify critical nodes in road networks. Instead of topology-only analysis of the road networks, both algorithms are based on the trip network that is represented by a tripartite graph through trajectory data mining. A synthetic experiment and a real case study based on Beijing taxi trajectories are performed. The experimental results verify the utility of the proposed algorithms.

Multi-Output Gaussian Processes for Crowdsourced Traffic Data Imputation

F. Rodrigues, K. Henrickson, and F. C. Pereira

A multi-output Gaussian process (GP) model for crowdsourced traffic speed data imputation is developed. The proposed approach allows to model the complex spatial and temporal patterns in the traffic data. While the Bayesian nonparametric formalism of GPs allows to model observation uncertainty, the multi-output extension based on convolution processes effectively enables them to capture complex spatial dependencies between nearby road segments. Using six months of crowdsourced traffic speed data (or "probe vehicle data") for several locations in Copenhagen, the proposed approach is empirically shown to significantly outperform popular state-of-the-art imputation methods.

A Bi-Objective Timetable Optimization Model for Urban Rail Transit Based on the Time-Dependent Passenger Volume

H. Sun, J. Wu, H. Ma, X. Yang, and Z. Gao

This paper develops a bi-objective timetable optimization model to minimize the total passenger waiting time and the pure energy consumption based on the real-world time-dependent smart-card automated fare collection data. In the model formulation, the total passenger waiting time is subjected to the train capacity, and the pure energy consumption is represented by the difference between the traction energy consumption and the regenerative energy within a given period. Numerical experiments based on the real-world data from Beijing Yizhuang metro line are conducted. The results indicate that the developed model can improve passenger service and reduce energy consumption efficiently in comparison with the timetable used currently.

An Online Ride-Sharing Path-Planning Strategy for Public Vehicle Systems

M. Zhu, X.-Y. Liu, and X. Wang

Public vehicle (PV) systems are efficient traffic-management platforms, which are envisioned to be a promising approach for solving traffic congestions and pollutions for future smart cities. PV systems provide online/dynamic peer-to-peer ride-sharing services for passengers aiming to serve sufficient number of customers with minimum number of vehicles and lowest possible cost. A key component of the PV system is the online ride-sharing scheduling strategy. In this paper, an efficient path planning strategy is proposed, which focuses on jointly reducing the computational complexity and ensuring passenger quality of service. The performance of the proposed solution such as reduction ratio of computational complexity is analyzed. The simulations based on the Manhattan taxi data set show that the computing time is reduced by 22% compared with the exhaustive search method under the same service quality performance.

One-Way Car-Sharing Profit Maximization by Means of User-Based Vehicle Relocation

A. Di Febbraro, N. Sacco, and M. Saeednia

One-way car-sharing systems, which allow customers to return vehicles to the stations where they were picked up, offer greater flexibility compared to conventional car-sharing services. Nevertheless, to guarantee this flexibility, such systems have to face difficult problems of vehicle relocation in order to be ready to satisfy as many trip reservations as possible. This paper proposes a user-based relocation methodology in which the users may accept to leave the car in a different location in exchange for fare discounts. The extensive analysis of results shows that, with the proposed user-based relocation strategy and without the operator-based relocation, the number of rejected reservations can be significantly reduced, even with a relatively small number of vehicles and, at the same time, the operator's profit can be increased.

Improving the Operational Efficiency of Buses With Dynamic Use of Exclusive Bus Lane at Isolated Intersections

J. Zhao and X. Zhou

This paper presents a dynamic exclusive bus lane (DBL) design, in which the exclusive bus lane at the exit can be dynamically used for the left turn buses and the opposing through buses during the various periods of a signal cycle. An optimization model is developed to simultaneously optimize the lane markings, signal timings, and location of the median opening using the average person delay as the objective. The results from the case study and extensive numerical analyses reveal the promising properties of the DBL design for reducing the average person delay. Moreover, using the DBL design can reduce the threshold of the allocation of the exclusive bus lane.

An AWID and AWIS X-By-Wire UGV: Design and Hierarchical Chassis Dynamics Control

J. Ni, J. Hu, and C. Xiang

In this paper, an all-wheel independently driven and all-wheel independently steered unmanned ground vehicle (UGV) is described. This paper investigates the hierarchical chassis dynamics control and tyre force control of the UGV in the remote control mode. As the key part in the control scheme, a yaw moment controller is proposed to deal with the oversteer problem of the UGV. The experiments in paved and off-road conditions are conducted to demonstrate the performance of the proposed controller.

Human-Centered Risk Assessment of an Automated Vehicle Using Vehicular Wireless Communication

D. Shin, B. Kim, K. Yi, A. Carvalho, and F. Borrelli

A vehicle to vehicle (V2V) wireless communication have been implemented and fused with a radar sensor to enhance the prediction performance of the automated driving vehicle. In order to decide active safety control intervention moment, a collision risk and a human reaction time are computed. This makes active safety system of automated vehicle to have more human-like driving intelligence. It was shown from both simulations and vehicle tests that the active safety intervention decision and vehicle control performance are significantly enhanced with the V2V communication.

On the Accuracy of Inter-Vehicular Range Measurements Using GNSS Observables in a Cooperative Framework

M. Tahir, S. S. Afzal, M. S. Chughtai, and K. Ali

In this paper, the authors propose a generalized version of a theoretical framework for the measurement and analysis of inter-vehicular ranges using global navigation satellite system (GNSS) observables between vehicles. Inter-vehicular range is an important measurement in cooperative positioning methods where it is mostly assumed that this measurement is available using some ranging method. Apart from traditional ranging methods, they have shown that GNSS observables can be used in four different ways to estimate inter-vehicular ranges with varying degree of accuracy depending mostly upon the environmental conditions. The developed framework compares the accuracy of inter-vehicular range measurement by actual field trials in different mobile environments using two vehicles capable to exchange information with each other.

SPERT: A Speed Limit Strategy for Recurrent Traffic Jams

J. R. D. Frejo and B. De Schutter

This paper proposes and simulates a speed limit controller for recurrent traffic jams (SPERT). SPERT is a simple yet efficient variable speed limit (VSL) control strategy based on the behavior of the optimal controller without any need for online optimization. The online implementation of SPERT is a simple rule-based controller that activates and deactivates the corresponding variable speed limit when the densities of the dominant bottlenecks (which are found offline) reach predefined thresholds. These thresholds are defined in order to activate and deactivate the speed limits at the same bottleneck density at which they would be activated or deactivated in the nominal case. The simulation results show that SPERT is able to approach the optimal behavior while eliminating online computational cost, increasing robustness, and outperforming previously proposed easy-to-implement VSL control algorithms.

A Context-Aware E-Bike System to Reduce Pollution Inhalation While Cycling

S. Sweeney, R. Ordóñez-Hurtado, F. Pilla, G. Russo, D. Timoney, and R. Shorten

This paper presents a system to reduce the amount of pollutants that are inhaled by cyclists using electric bicycles in urban environments. It is demonstrated that the ventilation rate of cyclists can be controlled using a cyber-physical, man–machine system that was designed and built at University College Dublin, Ireland. The motivation for the development of this system is due to the increasing awareness of the extremely negative impacts of transport-related urban air pollution on humans. Ventilation rate data measured from 18 different test subjects is presented to illustrate the efficacy of the system.

Vehicle Energy/Emissions Estimation Based on Vehicle Trajectory Reconstruction Using Sparse Mobile Sensor Data

X. Shan, P. Hao, X. Chen, K. Boriboonsomsin, G. Wu, and M. J. Barth

A new modal activity framework is proposed to estimate vehicle energy/emissions using sparse mobile sensor data. The valid vehicle dynamic states are identified including four driving modes, named acceleration, deceleration, cruising, and idling. The best valid vehicle dynamic state with the largest probabilities is selected to reconstruct the second-by-second vehicle trajectory between consecutive sampling times. Then vehicle energy/emissions factors are estimated based on operating mode distributions. The proposed model is calibrated and validated using the Next Generation Simulation's data sets, and shows better performance in vehicle energy/emissions estimation compared with the linear interpolation model.

A Scalable Reinforcement Learning Algorithm for Scheduling Railway Lines

H. Khadilkar

This paper describes an algorithm for scheduling bidirectional railway lines (both single- and multi-track) using a reinforcement learning (RL) approach. The primary advantage of the proposed algorithm compared to exact approaches is its scalability, and compared to heuristic approaches is its solution quality. Efficient scaling is ensured by decoupling the size of the state-action space from the size of the problem instance. Improved solution quality is obtained because of the inherent adaptability of reinforcement learning to specific problem instances. It is shown that the solution quality of the RL algorithm exceeds that of two prior heuristic-based approaches while having comparable computation times. Two lines from the Indian rail network are used for demonstrating the applicability of the proposed algorithm in the real world.

Driving Behavior Analysis through CAN Bus Data in an Uncontrolled Environment

U. Fugiglando, E. Massaro, P. Santi, S. Milardo, K. Abida, R. Stahlmann, F. Netter, and C. Ratti

This paper proposes a new methodology for near-real-time analysis and classification of driver behavior using a selected subset of CAN bus signals. Data have been collected in a completely uncontrolled experiment involving 54 people, where over 2000 trips have been recorded without any type of predetermined driving task on a wide variety of road scenarios. An unsupervised learning technique is proposed to cluster drivers in different groups, as well as a data subsampling strategy that allows reducing the size of the database of as much as 99% without impairing clustering performance.

PCANet-Based Convolutional Neural Network Architecture for a Vehicle Model Recognition System

F. C. Soon, H. Y. Khaw, J. H. Chuah, and J. Kanesan

The principal component analysis network-based convolutional neural network (PCNN) is presented for multi-class vehicle model recognition. This paper pinpoints only one discriminative local feature of vehicle, which is the vehicle headlamp, for vehicle model recognition. The proposed model eliminates the need of locating and segmenting the headlamp precisely. In particular, PCNN ascertains the effectiveness of both principal component analysis and CNN in extracting hierarchical features from a vehicle headlamp image and also reducing the computational complexity of the traditional CNN system. To further enhance the training procedure while still keeping the discriminative property of the network, the fully connected layer is updated by backpropagation optimized with stochastic gradient descent.

A Survey on Recent Advances in Vehicular Network Security, Trust, and Privacy

Z. Lu, G. Qu, and Z. Liu

This survey article starts with the necessary background of vehicular ad hoc networks (VANETs), followed by a brief treatment of main security services, which have been well studied in other fields. The authors then focus on an in-depth review of anonymous authentication schemes implemented by five pseudonymity mechanisms. Because of the predictable dynamics of vehicles, anonymity is necessary but not sufficient to thwart tracking attack. Thus, several location privacy protection mechanisms based on pseudonymity are elaborated to further. They also give a comprehensive analysis on various trust management models in VANETs. Finally, they give a much-needed update on the latest mobility and network simulators as well as the integrated simulation platforms. In sum, this paper is carefully positioned to avoid overlap with existing surveys by filling the gaps and reporting the latest advances in VANETs while keeping it self-explained.

Non-Cooperative Beacon Power Control for VANETs

F. Goudarzi and H. Asgari

An algorithm based on non-cooperative game theory is presented to control channel load due to beaconing for vehicular ad hoc networks (VANETs). Vehicles as players of the game adapt their beacon power, based on the proposed algorithm so that channel load is controlled at a desired level. The algorithm does not create overhead so there is no need to exchange excess information in beacons. Every vehicle just requires local information on channel load while good fairness is achieved across the network. In addition, the protocol has per-vehicle parameters, which makes it capable of meeting application requirements. Every vehicle can control its share of bandwidth individually based on its dynamics or requirements, while the whole usage of the bandwidth is controlled at an acceptable level. The algorithm is stable, computationally inexpensive, and converges in a short time that makes it suitable for the dynamic environment of VANETs.

Cooperative Vehicle Speed Fault Diagnosis and Correction

M. Pirani, E. Hashemi, A. Khajepour, B. Fidan, B. Litkouhi, S.-K. Chen, and S. Sundaram

Reliable estimation of vehicle speed is an active topic of research in the automotive industry and academia due to its technical challenges as well as applications to vehicle traction and stability control. In this direction, the emergence of new generations of communication technologies has brought new perspectives to traditional studies on vehicle speed estimation and control. To this end, this paper introduces a cooperative vehicle speed fault diagnosis and correction algorithm. The distributed part of the algorithm is based on a distributed function calculation algorithm for vehicle networks. The introduced algorithm enables each vehicle to gather some information from other vehicles in the network in a distributed manner and is robust to communication failures. A procedure to use such information for a single vehicle to diagnose and correct a possible fault in its own speed estimation/measurement is discussed. The functionality and performance of the proposed algorithms are verified via illustrative examples and simulation results.

MOHA: A Multi-Mode Hybrid Automaton Model for Learning Car-Following Behaviors

Q. Lin, Y. Zhang, S. Verwer, and J. Wang

This paper proposes a novel multi-mode hybrid automaton model for learning discrete and continuous dynamics of car-following behaviors from thousands of human drivers' real driving data. The idea is discretizing environmental variables on a coarse-grained level and obtaining a stateful model. Distinguished driving patterns represented by multiple modes are identified by partitioning such a model into groups of states. Corresponding groups of car-following models are identified on a fine-grained level from real-value time series data. The model is visualizable and interpretable for car-following behavior recognition, traffic simulation, and human-like cruise control. The experimental results using the next generation simulation data sets demonstrate its superior fitting accuracy over conventional models.

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