Scanning the Issue

A Bibliographic and Coauthorship Analysis of IEEE T-ITS Literature Between 2014 and 2016

X. Zhao, T. Wang, H. Lu, X. Sun, X. Wang, and F.-Y. Wang

Analysis from the aspects of productivity, topics, citations, usage, and coauthorship networks is presented. The most productive authors, institutions, countries/regions, and the most cited papers, most popular papers, as well as the most frequent topics and their trends are identified and analyzed. Collaboration patterns among contributors are revealed through author- and institution-level coauthorship. The results show that China is playing a critical role in ITS research during this period but the interinstitution collaborations are less prevalent than it used to be.

GNSS Position Integrity in Urban Environments: A Review of Literature

N. Zhu, J. Marais, D. Bétaille, and M. Berbineau

This paper provides an overview of the past and current literature discussing the global navigation satellite system (GNSS) integrity, which is defined as a measure of trust that can be placed in the correctness of the information supplied by the total system. Key differences between the GNSS integrity monitoring scheme in aviation domain and urban transport field are addressed. Possible challenges and complexities faced by mass-market commercial GNSS receivers in urban canyons are highlighted. Several open research issues of integrity monitoring in urban environments are pointed out.

Robust Longitudinal Control of Multi-Vehicle Systems—A Distributed H-Infinity Method

S. E. Li, F. Gao, K. Li, L.-Y. Wang, K. You, and D. Cao

The platooning of automated vehicles has the potential to significantly benefit road traffic. This paper presents a distributed H_∞ control method for multi-vehicle systems with identical dynamic controllers and rigid formation geometry. After compensating for the powertrain nonlinearity, the node dynamics in a platoon is mathematically described by a multiplicative uncertainty model. The platoon control system is then decomposed into an uncertain part and a diagonal nominal system through linear transformation and eigenvalue decomposition of the information-exchange-topology matrix. Robust stability, string stability, and distance tracking performance of the designed platoons are analyzed theoretically under the decoupled H_∞ framework. A comparative simulation with non-robust controllers is used to demonstrate the effectiveness of this method.

Efficient Indexing for Past and Current Position of Moving Objects on Road Networks

M. R. Abbasifard, H. Naderi, and O. Isfahani Alamdari

An integrated method called "PCI" (past-current-indexing) was proposed to index and store spatial–temporal data of the past and present simultaneously. The method can handle queries in both the time modes and it processes and generates both the past and present indices using an integrated set of processing resources. Two interconnected data structures were utilized to store indices of both the time modes. Connecting the index of different time modes enforces efficiency challenges due to difference in updating costs. Since the method stores the indices in the main memory, the way the structures are connected to each other makes it possible to transfer the current data to the section responsible for historical data. This method indexes them in the trajectory of moving objects at a minimum time expense. The map matching methods were used to increase the accuracy and reliability of query results. The effects of data reduction techniques were examined.

Fast Vehicle Detection Using a Disparity Projection Method

J. Chen, W. Xu, H. Xu, F. Lin, Y. Sun, and X. Shi

On account of the time complexity and the low robustness of the image matching algorithm, stereo vision is seldom used in large-scale scene. This paper puts forward a new vehicle detection method, which simplifies the massive Fourier transformation in the image matching process. The method converts the 2-D Fourier transformation to 1-D with the dimensionality reduction of reused Fourier transformation. Meanwhile, 1-D Fourier transformation of the fast image matching model is also derived. The coarse-to-fine pyramid search strategy is used according to the gradient information of each depth map adaptively. The adjacent area of the same depth is obtained with a larger matching weight, which improves the matching accuracy and robustness. The model can be used in the fitting and projection transformation of road plane after background extraction. Thus it reduces the complexity of vehicle segmentation and enhances the robustness of vehicle detection.

The Concept of Stimuli-Induced Equilibrium Point and Its Application in Ramp-Merging Control

K. Amezquita Semprun, P. C. Y. Chen, W. Chen, and Z. Zhao

In this paper, the novel concept of stimuli-induced equilibrium point is proposed to synthesize the speed and position references for automatic on-ramp merging systems. Based on the psychological field theory, the intensity of the stimuli that act upon a driver between two vehicles in a three-vehicle platooning configuration is mathematically modeled to calculate a point at which the stimuli resultant becomes zero. This approach intends to mimic drivers' decision process when certain distance separation with respect to the leader and

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follower vehicles is attained for safety. The location of this point is continuously updated according to the speed of the middle vehicle and the current traffic scenario. Such stimuli-induced equilibrium point has shown to improve the performance of existing automatic merging control schemes while increasing safety conditions by providing enough reaction time for drivers to avoid an eventual collision.

Infrared Pedestrian Segmentation Through Background Likelihood and Object-Biased Saliency

L. Li, F. Zhou, and X. Bai

This paper discusses the challenging problem of pedestrian segmentation in infrared images and proposes an effective background likelihood and object-biased saliency scheme to obtain the accurate pedestrian object. Background likelihood is developed to abstract the object representation based on the Gaussian mixture model soft decomposition. Kernel density estimation-based foreground estimation is proposed to obtain the saliency iteratively with better adaptable for the fuzzy contour of the infrared object. Finally, pedestrian boundary weight is employed to integrate the above two saliency maps for more intact and accurate results. Extensive experiments on real infrared images captured by intelligent transportation systems demonstrate that the authors' saliency algorithm consistently outperforms the state-of-the-art saliency detection methods, in terms of higher precision, F-measure, and lower mean absolute error.

Accelerated Evaluation of Automated Vehicles Using Piecewise Mixture Models

Z. Huang, H. Lam, D. J. LeBlanc, and D. Zhao

The process to certify highly automated vehicles has not yet been defined by any country in the world. Currently, companies test automated vehicles on public roads, which is time-consuming and inefficient. The authors proposed the accelerated evaluation concept, which uses a modified statistics of the surrounding vehicles and the importance sampling theory to reduce the evaluation time by several orders of magnitude while ensuring the evaluation results are statistically accurate. In this paper, the authors further improve the accelerated evaluation concept by using the piecewise mixture distribution models, instead of single parametric distribution models. The authors developed and applied this idea to forward collision control system reacting to vehicles making cut-in lane changes. The behavior of the cut-in vehicles was modeled based on more than 403 581 lane changes collected by the University of Michigan Safety Pilot Model Deployment Program.

Modeling the Imperfect Driver: Incorporating Human Factors in a Microscopic Traffic Model

M. Lindorfer, C. F. Mecklenbräuker, and G. Ostermayer

In this paper, the authors present the enhanced human driver model (EHDM), a time-continuous microscopic car-following model, which considers numerous characteristics attributable to the human driver. It is based on the popular intelligent driver model and the human driver model (HDM), a meta-model which enables the integration of human driving behavior into classical follow-the-leader models. They extend the HDM by adding variable, situation-dependent reaction times, different types of driver distraction, and driving errors to the model. Furthermore, they show that the EHDM provides a more thorough representation of human driving behavior compared with the HDM by performing dynamic traffic simulations and by validating both models with the aid of real-word vehicle data captured in an extensive field test.

Dynamic Eco-Driving's Fuel Saving Potential in Traffic: Multi-Vehicle Simulation Study Comparing Three Representative Methods

D. Fredette and U. Ozguner

The term dynamic eco-driving describes speed control schemes that utilize connected and automated vehicle technology for the purpose of saving fuel. If dynamic eco-driving is to be part of widespread fuel-saving endeavors, it must be determined to what extent this type of control remains effective in the presence of dense traffic. This paper presents multi-vehicle traffic simulations which begin to answer important questions surrounding dynamic eco-driving's potential for fuel savings in a mixed traffic environment. Three representative methods are tested in various traffic scenarios and the estimated fuel, trip time, and average speed results are compared. Independent variables include technology penetration rate and amount of traffic. It is shown that average mpg increases linearly with technology penetration rate and dynamic eco-driving causes an average increase in mpg regardless of traffic amount. Results are promising for the usefulness of these clever fuel-saving technologies, in high traffic as well as low.

Angle of Arrival-Based Cooperative Positioning for Smart Vehicles

A. Fascista, G. Ciccarese, A. Coluccia, and G. Ricci

Road safety applications require very accurate position estimation, which is not guaranteed by current global navigation satellite systems especially in urban environments. In this paper, a novel tracking algorithm is developed, which combines the potential of antenna array processing with a suitably designed cooperation strategy that exploits vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications. Specifically, angle of arrival estimates are opportunistically obtained from V2V and V2I beacon packet receptions, which then trigger asynchronous updates of the filter. A dynamic setting of the relevant parameters allows the proposed cooperative positioning algorithm to adapt to the different conditions found in urban contexts. Simulation under realistic conditions shows that high position accuracy can be achieved even in sparse scenarios, outperforming a natural competitor while keeping lightweight communication and low computational complexity.

Monte Carlo Localization on Gaussian Process Occupancy Maps for Urban Environments

A. Y. Hata, F. T. Ramos, and D. F. Wolf

The problem of vehicle localization using maps built from LiDAR data sets formed by partial measurements of the environment is discussed in this paper. The occupancy grid map (OGM) is the representation widely adopted for map-aided localization, though it requires a substantial amount of measurements of the environment, can not reconstruct unobserved areas, and the level of the details depends on the chosen map resolution. The Gaussian process occupancy map (GPOM) can suppress the limitations of OGM by making possible the representation of the environment in a continuous way and therefore, the reconstruction of areas that were not observed during the data gathering step. Considering the advantages of GPOM, the authors proposed the use of this representation for vehicle localization. Specifically, the Monte Carlo localization method was adapted to support GPOM. Results showed a more accurate position estimation of this solution compared to the OGM approach.

Training Drift Counteraction Optimal Control Policies Using Reinforcement Learning: An Adaptive Cruise Control Example

Z. Li, T. Chu, I. V. Kolmanovsky, and X. Yin

This paper investigates the problem of driver distraction detection using driving performance indicators from onboard kinematic measurements. First, naturalistic driving data from the integrated vehicle-based safety system program are processed, and cabin camera data are manually inspected to determine the driver's state (i.e., distracted or attentive). Second, existing driving performance metrics, such as steering entropy, steering wheel reversal rate, and lane offset variance, are reviewed against the processed naturalistic driving data. Furthermore, a nonlinear autoregressive exogenous (NARX) driving model is developed to predict vehicle speed based on the range (distance headway), range rate, and speed history. For each driver, the NARX model is then trained on the attentive driving data. The authors show that the prediction error is correlated with driver distraction. Finally, two features, steering entropy and mean absolute speed prediction error from the NARX model, are selected, and a support vector machine is trained to detect driving distraction.

Vehicle Type Recognition in Surveillance Images From Labeled Web-Nature Data Using Deep Transfer Learning

J. Wang, H. Zheng, Y. Huang, and X. Ding

By introducing the idea of unsupervised domain adaptation in transfer learning, the authors' work proposes a vehicle type recognition system that can extract transferable features across web-nature data and surveillance-nature data. Thus, large-scale annotated web-nature data, which is much easier to collect in real-world applications, can be applied to the task of vehicle type recognition from surveillance images. The system strongly reduces the burden of collecting labeled data for each specified surveillance system. The proposed method validated on a public data set was compared with widely used deep learning methods, and the obtained results demonstrate that their method outperforms the commonly used learning methods.

Simulation and Design of Fast Charging Infrastructure for a University-Based e-Carsharing System

K. N. Genikomsakis, I. Angulo Gutierrez, D. Thomas, and C. S. Ioakimidis

Carsharing is a mode of transportation that provides access to a set of vehicles in the form of organized short-term car rental, serving as a substitute for private car ownership with a number of transportation, environmental, and social benefits. Combining the mobility concept of carsharing with electric vehicles (EVs), referred to as e-carsharing, can contribute not only to more efficient use of the shared vehicles, but also to more sustainable urban mobility in smart cities. In this context, this paper advances the concept of university-based e-carsharing, to serve the mobility needs of an academic community in Bilbao, Spain, focusing on the technical design aspects to cover the energy requirements of the EV fleet of the proposed system through the installation of fast charging posts based on a battery-to-battery approach. In this regard, an MATLAB/Simulink model is implemented to simulate the fast charging infrastructure using real-world data collected from the university parking lot in order to represent the potential utilization of the EVs. The simulation results confirm the effectiveness of the proposed system design, ensuring that the energy demand of the EVs is successfully covered and concurrently the charging station batteries operate out of the low charge zone.

Dynamic Robust Sequencing and Scheduling Under Uncertainty for the Point Merge System in Terminal Airspace

Y. Hong, B. Choi, K. Lee, and Y. Kim

A dynamic robust aircraft sequencing and scheduling algorithm, performed in two stages, is proposed for the point merge system considering the uncertain flight time of aircraft. In the first stage of the proposed algorithm, for a static environment, deterministic robust solutions are determined based on the mixed integer linear programming. To consider the uncertainty, an extra buffer is introduced in the sequencing and scheduling algorithm, and the buffer size is analytically derived based on a deterministic robust counterpart problem. In the second stage, to compensate for unforeseen situations under a dynamic environment, the static solution determined in the first stage is adjusted by using the proposed heuristic algorithm. Additionally, the operational time of the proposed algorithm is extended with a low computational load by using a sliding time window. The performances of the proposed algorithm are verified through numerical simulations based on historical data analysis.

Event Detection on Roads Using Perceptual Video Summarization

S. S. Thomas, S. Gupta, and V. K. Subramanian

According to Annual Global Road Crash Statistics, nearly 1.3 million people die in road crashes every year, on average 3287 deaths a day. Road accident detection and vehicle behavior analysis is of great interest to the research community in intelligent transportation systems. Surveillance cameras are ubiquitous on the roads and capture videos round the clock. The enormous data collected by cameras may be time consuming and laborious to scrutinize the occurrence of an accident scenario present in the videos. There is a need to reduce the redundant nature of video so that its contents become succinct using the video summarization techniques. This paper presents perceptual video summarization techniques to enrich the speed of visualizing the accident content from a stack of videos. The problem of vehicle analysis is formulated as an optimization problem. The results establish the versatility of the proposed summarization model. This model is formulated using cost function based on the change in the appearance of perceptual features such as motion, color, shape, and size. A selective minimization of the cost function leads to an appropriate video summarization of the event. The experiments were conducted for different types of collision such as head-on collision, rear-end collision, single-vehicle collision, and intersection collision and summarized the events prior, during, and subsequent to the accidents. The reduction ratio achieved is small and true positive detection is higher compared with the conventional methods. The model used in this paper can be used for various surveillance purposes.

Wave Equation of Suppressed Traffic Flow Instabilities

B. K. P. Horn and L. Wang

There are literally hundreds of papers about traffic flow instabilities and their causes—some going back 80 years—but there is little about means for suppressing them. It is shown here that "phantom traffic jams"—the emergent behavior of systems of vehicles under "car following" control–can be suppressed using bilateral control. Bilateral control differs from "car following" and adaptive cruise control in that it—somewhat counterintuitively—uses information about the following vehicle—as well as about the leading vehicle. A damped wave equation is developed that describes the behavior of vehicles under bilateral control. This makes it possible to determine the speed of propagation of disturbances and their rate of decay—in both directions. While bilateral control is stable for all positive gain values, this kind of analysis makes it possible to further tune the control parameters of bilateral control.

Collision Risk Assessment Algorithm via Lane-Based Probabilistic Motion Prediction of Surrounding Vehicles

J. Kim and D. Kum

A risk assessment algorithm is proposed that can accurately estimate collision risks for a set of local path candidates via the lane-based probabilistic motion prediction of surrounding vehicles. This algorithm is verified by comparing the model probabilities with the maneuver probabilities derived from the NGSIM database as well as in two potentially dangerous driving scenarios.

A Dual PHD Filter for Effective Occupancy Filtering in a Highly Dynamic Environment

H. Fan, T. P. Kucner, M. Magnusson, T. Li, and A. J. Lilienthal

Environment monitoring remains a major challenge for mobile robotics, especially in densely cluttered or highly populated dynamic environments, where uncertainties originated from environment and sensor significantly challenge the robot's perception. This paper proposes an effective occupancy filtering method, called the dual probability hypothesis density (DPHD) filter, which models uncertain phenomena such as births, deaths, occlusions, false alarms, and miss detections by using random finite sets. The key insight of the authors' method lies in the connection of the idea of dynamic occupancy with the concepts of the phase space density in gas kinetic and the PHD in multiple target tracking. By modeling the environment as a mixture of static and dynamic parts, the DPHD filter can separate the dynamic part from the static one with a unified filtering process, but has a higher computational efficiency than the existing Bayesian occupancy filters. Moreover, an adaptive newborn function and a sensor detection model considering occlusions are proposed to improve the filtering efficiency further. Finally, a hybrid particle implementation of the DPHD filter is proposed, which uses a box particle filter with constant discrete states and an ordinary particle filter with a time-varying number of particles in a continuous state space to process the static part and the dynamic part, respectively. This filter has linear complexity in the number of grid cells occupied by dynamic obstacles. Real-world experiments on data collected by a LiDAR at a busy roundabout show their approach can handle monitoring of a highly dynamic environment in real time.

Safe Nonlinear Trajectory Generation for Parallel Autonomy With a Dynamic Vehicle Model

W. Schwarting, J. Alonso-Mora, L. Paull, S. Karaman, and D. Rus

In this paper, the authors introduce a parallel autonomy, or shared control, framework that computes safe trajectories for an automated vehicle, based on human inputs. They minimize the deviation from the human inputs while ensuring safety via a set of collision avoidance constraints. Their method achieves safe motion even in complex driving scenarios, such as those commonly encountered in an urban setting. They introduce a nonslip model suitable for handling complex environments with dynamic obstacles, and a nonlinear combined slip vehicle model including normal load transfer capable of handling static environments. They validate the proposed approach in two complex driving scenarios. First, in an urban environment that includes a left-turn across traffic and passing on a busy street. And second, under snow conditions on a race track with sharp turns and under complex dynamic constraints. They evaluate the performance of the method with various human driving styles.

Optimal Type-2 Fuzzy System for Arterial Traffic Signal Control

Y. Bi, X. Lu, D. Srinivasan, Z. Sun, and Z. Sun

Arterial traffic is the artery of urban transport and loads huge traffic pressure. A coordinated arterial traffic type-2 fuzzy logic control method is proposed. First, arterial traffic flow model and evaluation index model are set up, in which the turning vehicles and lane length are given full consideration. The traditional queue spillover phenomenon in the traffic models can be prevented here. Second, aiming at the coordination and dynamic uncertainty problem in arterial traffic, a coordinated arterial traffic type-2 fuzzy coordination control method is put forward. It consists of two-layer type-2 fuzzy controller, the basic control layer, and the coordination layer. Finally, the parameters of membership function and the rules of the two controllers are optimized alternately by gravitational search algorithm to configure their high-dimensional complex parameters. The simulation results verify the effectiveness of the proposed method from several aspects.

Physics-Based Optimization of Access Point Placement for Train Communication Systems

X. Zhang, A. Ludwig, N. Sood, and C. D. Sarris

Communication-based train-control (CBTC) systems are aimed at replacing conventional rail signaling with train control enabled by wireless communication between the train and a network of access points. This paper presents an efficient optimization framework of access point placement through combining a site-specific electromagnetic simulator and an optimization algorithm, ensuring that the system meets its operation standards with a minimum number of transmitters. Radio-wave propagation is modeled with the vector parabolic equation method, while the optimization of the access point location is pursued via the Hooke and Jeeves algorithm. Practical constraints and engineering considerations associated with the deployment of CBTC systems are taken into account. Numerical results are compared with experimental measurements in an actual CBTC deployment site, demonstrating the validity and usefulness of the proposed methodology.

A Panel Data Model-Based Multi-Factor Predictive Model of Highway Electromechanical Equipment Faults

Q. Yu, Y. Qin, P. Liu, and G. Ren

Highway electromechanical equipment plays an important role in highway operation and management. To discover the relationship between electromechanical equipment faults and impacting factors, which are traffic flow, temperature difference, relative humidity, and wind speed, a panel data model for the individual fixed effects model was developed based on data collected from six highways in Beijing. This paper showed the importance of traffic flow to highway electromechanical equipments, and can be potentially used to increase the service life of the equipments, while temperature, relative humidity, and wind speed were found to be significant to the electromechanical equipment failure rate. The contribution of the work would provide theoretical support for fault prediction and emphasize the importance of environment-related preventive maintenance on the highway electromechanical equipment.

Optimal Charging Schemes for Electric Vehicles in Smart Grid: A Contract Theoretic Approach

K. Zhang, Y. Mao, S. Leng, Y. He, S. Maharjan, S. Gjessing, Y. Zhang, and D. H. K. Tsang

A queuing network-based model to characterize the charging process of electric vehicle platoons in a renewable energy aided charging station is developed. Using a contract theoretic approach, optimal charging rate assignment and admission control schemes that maximize the utility of the charging station under certain charging constraints are proposed. The utility of the proposed schemes is evaluated through the IEEE 69-bus distribution test system.

Learning to Boost Bottom-Up Fixation Prediction in Driving Environments via Random Forest

T. Deng, H. Yan, and Y.-J. Li

A fixation prediction model via the random forest learning method is proposed to predict a driver's attentional areas in a driving environment. This model regards the color, intensity, and orientation of images as well as the saliency maps of GBVS, AIM, SR, and SUN as low-level (bottom-up) features, and uses the vanishing point and the center bias as high-level (top-down) traffic image features. The fixation prediction map is constructed by using a learning-based fusion method. Both the bottom-up and the top-down attentional mechanisms are incorporated into this model. Experimental results demonstrate that the proposed model can predict the drivers' fixation areas more accurately, outperforming many state-of-the-art bottom-up saliency models in the driving environments.

Track Fusion and Behavioral Reasoning for Moving Vehicles Based on Curvilinear Coordinates of Roadway Geometries

K. Jo, M. Lee, and M. Sunwoo

This paper presents track fusion and behavioral reasoning for moving vehicles in close proximity based on the curvilinear coordinates of roadway geometries. The inferred track and behavior of other vehicles can be used to perform safe actions in intelligent vehicle applications and autonomous driving. Vehicle detections from multiple perception sensors are integrated using track-to-track (T2T) fusion based on a cross-covariance method, and this T2T fusion is performed with curvilinear coordinates created using prebuilt roadway geometry on a digital map. The coordinate conversion to curvilinear space has many benefits for behavioral reasoning and tracking, such as constraining problem spaces and dimensions. A machine learning classifier based on a support vector machine is then applied to deduce the behavior of nearby vehicles. The algorithms presented here for track fusion and behavioral reasoning based on curvilinear coordinates have been verified through experiments in various real traffic scenarios.

DIFS: Distributed Interest Forwarder Selection in Vehicular Named Data Networks

S. H. Ahmed, S. H. Bouk, M. A. Yaqub, D. Kim, and H. Song

During the last two decades, vehicular networking (VN) architectures have been under serious discussion. However, when the authors depend on IP-based 802.11p for vehicular networks, there is always room available for improvement. In this paper, a newly introduced future Internet architecture known as named data networking (NDN) is considered for a reliable or more robust communication in VNs. To be specific, a distributed interest forwarder selection (DIFS) scheme has been proposed that mitigates the interest broadcast storm in NDN aided VN. In DIFS, a vehicle sends an interest packet piggybacking its location, distance to the neighbors, and speed. In this case, the immediate neighbors do not have the requested content and rank themselves to be an eligible interest forwarder by using multiple attributes. Additionally, every intermediate vehicle uses a digital map to be selected as forwarders in both (forward and backward) directions of the consumer. Simulations show that DIFS satisfies more interest packets with less delay as compared to the recent state-of-the-art forwarding solutions.

Performance Analysis of Multi-Source Multi-Destination Cooperative Vehicular Networks With the Hybrid Decode-Amplify-Forward Cooperative Relaying Protocol

H. Xiao, Z. Zhang, and A. T. Chronopoulos

This paper provides symbol-error-rate (SER) performance analysis and minimum power allocation for multi-source multi-destination cooperative vehicular networks using the hybrid decode–amplify–forward (HDAF) cooperative relaying protocol. Previous studies of power allocation minimize the outage probability subject to a total power constraint. The authors' approach aims to minimize the power allocation in order to maintain the SER below a specific threshold and thus it achieves lower power consumption. Numerical tests show that HDAF has significantly reduced SER compared with the forward strategies of amplify-and-forward (AF) and decode-and-forward (DF). Furthermore, the power consumption in their proposed approach is much less than that in AF and DF.

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