Scanning the Issue

Analysis and Prediction of Regional Mobility Patterns of Bus Travellers Using Smart Card Data and Points of Interest Data

G. Qi, A. Huang, W. Guan, and L. Fan

Mobility patterns at the region level can provide more macroscopic and intuitive knowledge on how people gather in or depart from the region. Using smart card data (SCD) and points of interest (POI) data, a multi-step methodology which integrates the inner-restricted fuzzy C-means clustering, nonnegative tensor factorization and artificial neural network is proposed and implemented in this paper. It overcomes the difficulties in region division, pattern extraction, and prediction. The bus SCD and POI data in Beijing city are utilized to prove the usefulness of the methodology. The analyzed results show that the proposed methodology has a good performance on predicting the regional mobility patterns based on the regional properties. These research achievements can not only provide deep insight on the human mobility patterns at the region level, but also support the evidence-based and forward-looking urban planning and intelligent transportation management.

Predicting the EEG Level of a Driver Based on Driving Information

H. S. Kim, D. Yoon, H. S. Shin, and C. H. Park

For safe and comfortable driving, it would be useful to detect when drivers are being overloaded. Analyzing driver's workload using an electroencephalograph (EEG) is useful for this purpose. However, it is very inconvenient to obtain an EEG during actual driving, since the measuring device needs to be attached to the driver. In this paper, the authors develop a model to predict the driver's EEG level utilizing basic information obtained while the vehicle is being driven. They divided the EEG values into "normal" and "overload" classes, and extracted useful features from the vehicle driving information, such as RPM, speed, lane changes, and turns. A classification model using a support vector machine was built to predict normal and overload states during actual driving. They evaluated the performance of the proposed method using field-of-test data collected when driving on actual roads, and suggest directions for future research based on an analysis of the experimental results.

Efficient Data Dissemination for Urban Vehicular Environments

M. Chaqfeh, H. El-Sayed, and A. Lakas

Vehicular communication systems play an important role in the context of smart cities. These systems require efficient data dissemination that guarantees full coverage with minimum overhead and delay. Existing data dissemination protocols often rely on extra communication to gather knowledge about the neighborhood and set the dissemination criteria accordingly. This extra communication poses serious overhead issues that affect the scalability of data dissemination, which is an essential criterion under high-density scenarios. An efficient multi-directional data dissemination protocol (EDDP) is proposed and evaluated. EDDP considers the requirements of an urban vehicular environment without requiring extra communication overhead. The simulation results show that the EDDP can effectively disseminate traffic data with high delivery ratio and a minimized overhead.

A Novel Motion Plane-Based Approach to Vehicle Speed Estimation

M. Famouri, Z. Azimifar, and A. Wong

A novel motion plane-based approach for vehicle speed estimation is proposed, which addresses the problem of projection displacement difference. In the proposed method, the center of the vehicle license plate is considered as the vehicle reference point and estimates the hypothetical plane (named motion plane) on which the license plate moves. Subsequently, the plate position is mapped on the motion plane and the displacement is then calculated, thus mitigating the effects of PPD. To estimate the motion plane, a texture-based shape-from-template technique is used.

Adaptive Rolling Smoothing With Heterogeneous Data for Traffic State Estimation and Prediction

X. Chen, S. Zhang, L. Li, and L. Li

The adaptive smoothing method (ASM) is one of the most frequently used approaches to estimate traffic states. However, the fixed filter parameters used in existing approaches sometimes fail to characterize traffic dynamics well. To better capture generation, propagation, and mitigation dynamics of traffic congestion, the authors propose an adaptive rolling smoothing (ARS) approach by dynamically tuning the filter parameters in a rolling horizon scheme for online applications. The fusion of heterogeneous traffic data combines aggregate traffic measurements and disaggregate information. A nonlinear traffic flow filter based on the virtual trajectory algorithm is established to reconstruct the spatial–temporal traffic state and estimate experienced travel times of individual vehicles. The results demonstrate the capability and effectiveness of the proposed ARS approach in the historical traffic state estimation and short-term traffic flow prediction.

Deep Reinforcement Learning for Event-Driven Multi-Agent Decision Processes

K. Menda, Y.-C. Chen, J. Grana, J. W. Bono, B. D. Tracey, M. J. Kochenderfer, and D. Wolpert

Temporally extended actions pose unique problems for multi-agent reinforcement learning. The authors show that

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using fixed time step simulation compromises the quality of policies learned and that the quality deteriorates as the number of agents increases. To address this problem, they develop a deep reinforcement learning algorithm using event-driven simulation that learns optimal policies when actions are temporally extended. They show that their algorithm is capable of learning optimal policies in two cooperative domains, one involving real-time bus holding control and another involving wildfire fighting with unmanned aircraft.

Coordinated Transit Signal Priority Model Considering Stochastic Bus Arrival Time

L. T. Truong, G. Currie, M. Wallace, C. De Gruyter, and K. An

This paper presents an advanced transit signal priority (ATSP) control model that considers bus progression at downstream intersections when giving priority at upstream intersections and stochastic bus arrival times. At the center of the ATSP control model is a stochastic programming model formulated to find the optimum priority strategies at each intersection of interest, which minimizes bus delays while having the least negative impact on general traffic. The uncertainty in bus arrivals is taken into account by considering stochastic bus dwell times. The ATSP control is implemented in a traffic micro-simulation environment and compared with conventional transit signal priority (CTSP) control.

Driver and Passenger Identification From Smartphone Data

B. I. Ahmad, P. M. Langdon, J. Liang, S. J. Godsill, M. Delgado, and T. Popham

This paper discusses the problem of identification or recognition of drivers and passengers from their smartphone data, possibly within a connected vehicle environment. It highlights several relevant practical considerations, presents an overview of key existing techniques, and then proposes a novel simple, yet effective, identification approach. The proposed method relies on extracting salient features pertaining to the user entry behavior from processed smartphone data and subsequently applying a suitable classifier followed by a decision criterion. The experimental evaluation with various vehicles and scenarios demonstrate the efficacy of the introduced ubiquitous approach.

Behavior Monitoring Using Learning Techniques and Regular-Expressions-Based Pattern Matching

H.-S. Shin, D. Turchi, S. He, and A. Tsourdos

This paper proposes a new behavior monitoring approach that integrates two main anomaly detection trends, knowledge-based and learning-based approaches. In a general sense, the proposed method consists of two main steps: classification of target behaviors in sequences of behavior features and comparison of the behavior feature sequences with reference patterns. Note that the authors define the reference patterns using *a priori* on the basis of specific knowledge, automatically learned by means of a supporting NN or both. The proposed method is tested through numerical simulations and experiments, and is also compared with well-established techniques in the field. The results clearly show that the proposed approach is an effective way of assessing the regularity level of target behaviors and could potentially overcome the limitations of knowledge-based and learning-based approaches.

Predictive Maneuver Planning for an Autonomous Vehicle in Public Highway Traffic

Q. Wang, B. Ayalew, and T. Weiskircher

A predictive maneuver planning method is proposed that integrates both discrete maneuver planning and motion trajectory planning for an autonomous vehicle. Therein, a reference speed pre-planning is done for each lane at each time step of the prediction horizon, based on the likely motion of the autonomous vehicle and other surrounding object vehicles subject to sensor noise and environmental disturbances. To facilitate real-time feasible computations, the mixed-integer nonlinear programming problem that results from naive formulations of the joint optimal maneuver selection and trajectory planning tasks, a novel relaxation scheme is outlined. The final proposed approach, which effectively computes an optimal sequence of maneuvers for a horizon, is evaluated against an alternative that compute one optimal maneuver per horizon and is shown to result in improved performance in complex scenarios.

Multipath Mitigation for GNSS Positioning in an Urban Environment Using Sparse Estimation

J. Lesouple, T. Robert, M. Sahmoudi, J.-Y. Tourneret, and W. Vigneau

Multipath (MP) remains the main source of error when using global navigation satellite systems (GNSS) in a constrained environment, leading to biased measurements and thus to inaccurate estimated positions. This paper formulates the GNSS navigation problem as the resolution of an overdetermined system whose unknowns are the receiver position and the potential biases affecting GNSS measurements. The authors assume that only a part of the satellites are affected by MP, i.e., that the unknown bias vector has several zero components, which allows sparse estimation theory to be exploited. This leads to a least absolute shrinkage and selection operator problem that is solved using a reweighted-ℓ_1 algorithm. The weighting matrix of this algorithm is designed carefully as functions of the satellite carrier-to-noise density ratio and the satellite elevations. Experimental validation conducted with real GPS data shows the effectiveness of the proposed method as long as the sparsity assumption is respected.

Hierarchical Fuzzy Logic-Based Variable Structure Control for Vehicles Platooning

Y. Ma, Z. Li, R. Malekian, R. Zhang, X. Song, and M. A. Sotelo

A new variable structure control approach for vehicles platooning is proposed using the two-layer fuzzy structure.

The predecessor-successor information flow is used to achieve the string stability in large platoon. A Lyapunov method with exponential stability is used to develop performance boundaries for arbitrary initial spacing and velocity errors and to determine the controller parameters instead of H∞/H2 norm construction. Simulation of a ten-vehicle large platooning with two spacing policies shows that the control performance of the newly proposed method is effective.

Traffic Light Recognition With High Dynamic Range Imaging and Deep Learning

J.-G. Wang and L.-B. Zhou

A novel real-time method is proposed to recognize traffic light with high dynamic imaging and deep learning. Traffic light candidates are robustly detected from low exposure/dark frames and accurately classified using a deep neural network in consecutive high exposure/bright frames. This dual-channel mechanism can make full use of undistorted color and shape information in dark frames as well as rich context in bright frames. The performance is further boosted by incorporating temporal trajectory tracking. In order to speed up the algorithm, a prior detection mask is generated to limit the potential search regions. Intensive experiments on a large dual-channel dataset show that the proposed approach outperforms the state-of-the-art real-time deep learning object detector, which could cause more false alarms because it uses bright images only. The algorithm has been integrated into the author's autonomous vehicle and can work robustly on real roads.

A Bi-Level Model to Resolve Conflicting Transit Priority Requests at Urban Arterials

M. Xu, K. An, Z. Ye, Y. Wang, J. Feng, and J. Zhao

This paper develops a bi-level optimization model to resolve the problem of conflicting transit signal priority (TSP) requests at urban arterials. A hybrid genetic algorithm is used to solve the proposed model. An arterial with seven intersections in Nanjing, China, is selected to evaluate the performance of the proposed model. Three other models (the baseline model without TSP, Model 1 with the regular TSP and the classical coordination, and Model 2 with the lower model and the classical coordination) are also utilized to conduct the comparison analysis. The results show the proposed model can significantly reduce the bus passenger delay and stops compared to the three other models and meanwhile the operation of other vehicles will not turn worse.

Two-Stage Stochastic Programming Based on Particle Swarm Optimization for Aircraft Sequencing and Scheduling

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

A two-stage stochastic programming algorithm based on particle swarm optimization is proposed for an optimal and robust design in the aircraft sequencing and scheduling problem. The first and second stage decision problems are defined as aircraft sequencing and scheduling, respectively, and the uncertainties that arise from the aircraft flight time between two successive fixes are considered. The numerical analysis is performed to determine the appropriate number of scenarios required in the second stage of the proposed algorithm. Additionally, the performance of the proposed algorithm is evaluated and compared with that of deterministic and other stochastic approaches. The results show that the proposed algorithm is less conservative than the deterministic algorithm and more preferable than other stochastic approaches when a short computing time is required.

Prediction-Based Eco-Approach and Departure at Signalized Intersections With Speed Forecasting on Preceding Vehicles

F. Ye, P. Hao, X. Qi, G. Wu, K. Boriboonsomsin, and M. J. Barth

This paper proposes a prediction-based eco-approach and departure (EAD) strategy that enable online preceding vehicle future state prediction in urban traffic embedded with an enhanced vehicle trajectory planning algorithm. Three state-of-the-art nonlinear regression models are evaluated in terms of prediction accuracy and efficiency for short-term speed forecasting of the preceding vehicle. The experimental results demonstrate that the proposed prediction-based EAD system can achieve better fuel economy and emission reduction in urban traffic and queue at intersections compared to conventional car following model and the existing EAD algorithm without prediction in real time.

Cooperative Method of Traffic Signal Optimization and Speed Control of Connected and automated Vehicles at Isolated Intersections

B. Xu, X. J. Ban, Y. Bian, W. Li, J. Wang, S. E. Li, and K. Li

A cooperative method of traffic signal control and vehicle speed optimization is proposed for connected and automated vehicles, which optimizes the traffic signal timing and vehicles' speed trajectories at the same time. The simulation studies are conducted to compare the proposed method with benchmark methods of which the results show significant improvement of transportation efficiency and fuel economy in this method.

Measuring the Motion of Vulnerable Road Users Relative to Moving HGVs

Y. Jia and D. Cebon

In this paper, the authors report on measuring the motion of a cyclist moving adjacent to a heavy goods vehicle, from the detections of an array of ultrasonic sensors installed along the side of the vehicle, where most fatal collisions with cyclists occur. The measurements are used in a prototype collision avoidance system that predicts the future relative motion and assesses the likelihood of a collision. The off-the-shelf ultrasonic sensors can only output distance information, which is not sufficient for cyclist motion estimation. A method combining quadratic programming and Kalman filtering is developed in this paper for recovering the bearing angles of the cyclist from the detected distances provided by the sensors.

The algorithms are developed for use in real time and practical constraints are considered.

Stable and Flexible Multi-Vehicle Navigation Based on Dynamic Inter-Target Distance Matrix

J. Vilca, L. Adouane, and Y. Mezouar

A modular multi-layer and multi-controller architecture for dynamic navigation in formation of a group of autonomous vehicles is proposed. This architecture takes advantage of the leader-follower and behavior-based approaches to obtain a flexible, safe and smooth strategy of formation navigation and reconfiguration in different contexts (e.g., dynamic and cluttered environment). In addition, an analytic formulation of the maximum linear and angular velocities of the leader is proposed in order to guarantee the asymptotic stability (based on Lyapunov synthesis) of the fleet navigation (steady and reconfiguration phase). The safety of the fleet is formally demonstrated using an appropriate reconfiguration matrix, which takes into account the vehicles' set-points inter-distances to avoid any inter-vehicles collisions. The simulations and experiments in different scenarios are performed to demonstrate the flexibility, reliability, and efficiency of the proposed overall control architecture.

Vehicle Localization at an Intersection Using a Traffic Light Map

C. Wang, H. Huang, Y. Ji, B. Wang, and M. Yang

A method of intersection localization using traffic lights map is proposed. Traffic lights with significant visual characteristics in the urban environment are used as landmarks. The localization of the vehicle can be converted into a problem of estimating the state of the system from the system's observation. Combined with the location and height information of traffic lights provided by the high-precision map, the Extended Kalman Filter is used to fuse the vision detection results of the traffic lights with the inertial measurement unit information. The experiments demonstrate that the method proposed in this paper improves the lateral localization accuracy and the accuracy of vehicle's yaw angle.

Driving Performance Indicators of Electric Bus Driving Technique: Naturalistic Driving Data Multicriterial Analysis

M. Bartłomiejczyk

Energy-efficient driving technology—ecodriving—is one of the methods that allows to reduce the energy consumption of electric vehicles. This is especially important for battery vehicles. Battery capacity is limited, so reduction in energy consumption extends the drive range. This paper presents a novel method of analysis and optimization of electric bus driving parameters based on measurements and the MCDA method. Th author proceeded with data analysis of vehicle data logger recordings using the most important PCA extracted factors. The influence of several factors was estimated. The presented research was based on real measurement data obtained in urban traffic.

Realizing Railway Cognitive Radio: A Reinforcement Base-Station Multi-Agent Model

C. Wu, Y. Wang, and Z. Yin

The rapid motion characteristics of the train make the wireless spectrum environment unstable and discontinuous. The reinforcement base-station multi-agent system model is proposed for the chain-like distribution and cascade operation of the cognitive base stations along the railway. It is proven that the model can significantly improve the probability of successful data transmission in the railway wireless communication network, and greatly reduce the number of wireless channels switching. In addition, the effect of Dual$\sim$ \varepsilon-greedy mechanism on communication performance is discussed. The reinforcement base-station multi-agent model in this paper provides a new idea for realizing the railway cognitive radio and comprehensively solves the problem of low spectrum efficiency of cognitive radio in rail transit.

Traffic Light Scheduling for Pedestrian-Vehicle Mixed-Flow Networks

Y. Zhang, K. Gao, Y. Zhang, and R. Su

Owing to the recent trend of developing pedestrian friendly urban areas and the advent of the age of mobile pedestrianism, making pedestrians happy is certainly one of the factors that need to be considered seriously. In this paper, the authors propose a traffic signal scheduling strategy for an urban traffic network with consideration of both pedestrians and vehicles, in which a novel mathematical model consisting of several logic constraints is first developed. With the aim to minimize the tradeoff of the delays between pedestrians and vehicle, both the mathematical technique and the meta-heuristic approach are adopted to solve the scheduling problem: mixed integer linear programming (MILP) and discrete harmony search algorithm (DHS). Finally, case studies illustrate the effectiveness of their real-time traffic light scheduling strategy, and the potential impact of the pedestrian movement to the vehicle traffic flows.

Development and Testing of a Real-Time WiFi-Bluetooth System for Pedestrian Network Monitoring, Classification, and Data Extrapolation

A. Lesani and L. Miranda-Moreno

A real-time pedestrian monitoring system provides information about traffic flow (volume), speeds, travel times, and time spent in areas of interest. This is useful in travel information systems and crowd management strategies, as well as in planning and emergencies of public spaces such as airports, parks, malls, and university campuses. While there are technologies that can obtain count data at specific locations, most technologies cannot provide origin–destination information, trip paths, travel times, or time spent. To overcome these shortcomings, the author's designed system captures the unique media access control (MAC) addresses of wireless devices carried by pedestrians or cyclists at different points, send them to their cloud-based platform to be processed. Their platform analyzes the data to track people movement in the network, generate origin-destination database, measure average speed (travel time) of the users, classify users in

pedestrian or cyclists, and extrapolate detected trips to estimate traffic flow.

A Novel Strategy for Road Lane Detection and Tracking Based on a Vehicle's Forward Monocular Camera

D. C. Andrade, F. Bueno, F. R. Franco, R. A. Silva, J. H. Z. Neme, E. Margraf, W. T. Omoto, F. A. Farinelli, A. M. Tusset, S. Okida, M. M. D. Santos, A. Ventura, S. Carvalho, and R. S. Amaral

This paper aims to present a novel strategy for lane detection and tracking which fits the functional requirement to deploy DAS features such as lane departure warning (LDW) and lane keeping assist (LKA). Therefore, digital image processing has been established in three levels. At the low-level, the input image dimensionality is reduced from three to one layer, the sharpness is improved, and region of interest (ROI) is defined based on the minimum safe distance from the vehicle ahead. The feature extractor for lane edges detection design is part of the mid-level processing and the lane tracking strategy development is discussed in the high-level stage. Hough transform and a shape-preserving spline interpolation are deployed to achieve a smooth lane fitting. The experimental outcomes have been qualitatively and quantitatively evaluated using a ground truth comparison. Finally, the proposal strategy shows the accuracy levels, including scenarios with shadows, curves, and road slope.

Overall Traffic Mode Prediction by VOMM Approach and AR Mining Algorithm With Large Scale Data

C. Yuan, X. Yu, D. Li, and Y. Xi

A new method combining VOMM with coupling factors is presented to forecast the overall traffic mode transition in Shanghai, China. The proposed method first defines the overall traffic mode to describe traffic status of whole transport network, by the means of clustering algorithm. Then a VOMM with PST method is presented to study the transition law of traffic mode series and make prediction on the next mode. In order to make the prediction result more accurately, the coupling factors are introduced to modify the previous prediction, which reflect the influence of the ramp information to the predicting network. The association rule is utilized to discover key coupling factors. The experimental results show that the proposed method could improve the prediction accuracy compared to previous methods.

New Multi-Hop Clustering Algorithm for Vehicular Ad Hoc Networks

D. Zhang, H. Ge, T. Zhang, Y.-Y. Cui, X. Liu, and G. Mao

A novel passive multi-hop clustering algorithm (PMC) vehicular ad hoc networks (VANETs) is proposed. The PMC algorithm is based on the idea of multi-hop clustering algorithm, which ensures the coverage and stability of cluster. In the cluster head selection phase, a priority-based neighbor following strategy is proposed to select the optimal neighbor nodes to join the same cluster. This strategy makes the inter-cluster nodes have high reliability and stability. By ensuring the stability of the cluster members and selecting the most stable node as the cluster head in the N-hop range, the stability of the clustering is greatly improved.

Traffic Data Reconstruction via Adaptive Spatial-Temporal Correlations

Y. Wang, Y. Zhang, X. Piao, H. Liu, and K. Zhang

A novel temporal and adaptive spatial constrained low-rank approach is proposed to enhance the reconstruction performance of missing traffic data. The proposed approach exploits the global feature of traffic data by using the low-rank representation, as well as the local feature with the spatial-temporal correlation of traffic network. To explore the temporal evolvement characteristics and the spatial similarity of road links, a time series constraint and an adaptive Laplacian regularization spatial constraint are presented and then integrated to build a strong ensemble data reconstruction model. The experimental results show that the author's approach has the explanation power of traffic data, and the strong superiority of traffic data reconstruction for various structural loss modes.

Enhancing Communication-Based Train Control Systems Through Train-to-Train Communications

X. Wang, L. Liu, T. Tang, and W. Sun

A novel urban rail transit wireless communication model is established using FlashLinQ-based T2T communications. The quantified resilience is also introduced as a system metric to evaluate the preservation and recovery performance of communication-based train control (CBTC) systems. A new cognitive control scheme based on LTE-M with T2T communication to enhance the quality of service (QoS) and the resilience of multi-train CBTC systems is presented. Q-learning is used to generate optimal control strategies considering both wireless communication parameters adaption and train control parameters. The results show that the QoS and resilience of CBTC systems can be enhanced using the introduced T2T scheme.

Optimal Speed Control of a Heavy-Duty Vehicle in Urban Driving

M. Held, O. Flärdh, and J. Mårtensson

The energy optimal control of a heavy-duty vehicle in urban environments is addressed. The problem is solved both offline using Pontryagin's maximum principle and online using an MPC with a quadratic program formulation. The velocity of the vehicle is constrained by both upper and lower limits in order not to deviate too much from a normal driving pattern. These constrains are based on a statistical analysis of similar vehicles in live operation. Sensitivity analyses are performed to investigate how variations in the velocity constraints and the control horizon influence the energy consumption.

Calibrating a Bayesian Transit Assignment Model Using Smart Card Data

M. Rahbar, M. Hickman, M. Mesbah, and A. Tavassoli

The individual travel history data available from automated fare collection (AFC) systems brings the opportunity of understanding the individual's travel behavior, which is necessary to develop a transit assignment model. By combining the prior knowledge about the transit network with the AFC data, this paper proposes a Bayesian hierarchical model to estimate attributes of travel time components and to calibrate a transit

assignment model. In this model, route choices are represented by a multinomial logit model, and its coefficients are estimated via a Markov chain Monte Carlo method. In order to assess the model fitness, the root-mean-square error (RMSE) between each posterior estimate and the actual observation is computed. The %RMSE at 15% indicates the high predictive power of the proposed model.

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