Scanning the Issue and Beyond: Computational Transportation and Transportation 5.0

Welcome to our fifth issue of the year with my comments on computational transportation and transportation 5.0, and some random thoughts triggered by Germany's recent ***INDUSTRIE 4.0*** initiative. Please check IEEE-TITS (http://www.weibo.com/u/3967923931) on Weibo (an extended Chinese version of Twitter), https://www.facebook.com/IEEEITS on Facebook, and IEEEITS (https://twitter.com/IEEEITS) on Twitter for any news regarding IEEE ITSS, IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS, and *IEEE Intelligent Transportation Systems Magazine*. The three sites are still under development and your participations and suggestions are extremely welcome.

SCANNING THE ISSUE

Supervisory Power Management Control Algorithms for Hybrid Electric Vehicles: A Survey

Andreas A. Malikopoulos

The growing necessity for environmentally benign hybrid propulsion systems has led to the development of advanced power management control algorithms to maximize fuel economy and minimize pollutant emissions. This paper surveys the control algorithms for hybrid electric vehicles (HEVs) and plug-in HEVs (PHEVs) that have been reported in the literature to date. The exposition ranges from parallel, series, and power-split HEVs and PHEVs and includes a classification of the algorithms in terms of their implementation and the chronological order of their appearance. Remaining challenges and potential future research directions are also discussed.

Multiple-Human Tracking by Iterative Data Association and Detection Update

Lu Wang, Nelson Hon Ching Yung, and Lisheng Xu

This paper presents a multiple-human tracking approach that takes the single-frame human detection results as input and associates them to form trajectories while improving the original detection results by making use of reliable temporal information in a closed-loop manner. It works by first forming tracklets from which reliable temporal information is extracted and then refining the detection responses inside the tracklets to improve the accuracy of tracklets quantities. Local conservative tracklets association is performed, and reliable temporal information is propagated across tracklets. The global tracklet association is done finally to resolve association ambiguities. Experimental results show that the proposed approach improves both the association and detection results.

Adaptive Vehicle Navigation With En Route Stochastic Traffic Information

Lin Xiao and Hong K. Lo

This paper develops an adaptive approach for vehicle navigation in a stochastic network with real-time en route traffic information. This stochastic adaptive approach is formulated as a probabilistic dynamic programming problem and solved through a backward recursive procedure. The formulation, as a modeling framework, is designed to be able to incorporate various sources of information and real-time traffic states to improve the routing quality. In this paper, it is proven that the approach outperforms deterministic instantaneous shortest paths in a statistical sense. We also analyze the algorithm's computational efficiency. Results from numerical example are included to illustrate the performance of the adaptive routing policy generated by the formulation.

A Two-Objective Timetable Optimization Model in Subway Systems

Xin Yang, Bin Ning, Xiang Li, and Tao Tang

The train timetable optimization problem in subway systems is to determine arrival and departure times for trains at stations so that the resources can be effectively utilized and the trains can be efficiently operated. Because the energy saving and the service quality are given more attention, this paper proposes a timetable optimization model to increase the utilization of regenerative energy and simultaneously shorten the passenger waiting time. First, we formulate a two-objective integer programming model with headway time and dwell time control. Second, we design a genetic algorithm with binary encoding to find the optimal solution. Finally, we conduct numerical examples based on the operation data from Beijing Yizhuang subway line of China. The results illustrate that the proposed model can save energy by 8.86% and reduce passenger waiting time by 3.22% in comparison with the current timetable.

Delay-Tolerant Stochastic Algorithms for Parking Space Assignment

Arieh Schlote, Christopher King, Emanuele Crisostomi, and Robert Shorten

This paper introduces and illustrates some novel stochastic policies that assign parking spaces to cars looking for an available parking space. Both the main features of a single park, i.e., how a car could conveniently decide whether to try its luck at that parking lot or try elsewhere, and the case when more parking spots are available and how to choose the best one, are analyzed. Discussed are the practical requirements of the proposed strategies in terms of infrastructure technology and vehicles' equipment and the mathematical properties of the proposed algorithms in terms of robustness against delays, stability, and reliability. Preliminary results obtained from

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simulations are also provided to illustrate the feasibility and the potential of our stochastic assignment policies.

Detecting Road Traffic Events by Coupling Multiple Timeseries With a Nonparametric Bayesian Method

Shiming Yang, Konstantinos Kalpakis, Alain Biem

We propose a new method for detecting traffic events that impact road traffic conditions by extending the Bayesian robust principal component analysis (RPCA) approach. Our method couples multiple traffic data streams so that they share a certain sparse structure. The traffic data streams are measurements of different physical quantities by different nearby sensors. We experimentally analyze the detection performance of the proposed coupled Bayesian RPCA using real data from loop detectors on the Minnesota I-494 roadway and find that our method significantly improves the detection accuracy when compared with the traditional PCA and the noncoupled Bayesian RPCA.

Driver/Vehicle Response Diagnostic System for the Vehicle-Following Case

Vadim A. Butakov and Petros A. Ioannou

This paper considers the problem of identifying the driver/vehicle characteristics by processing real-time driving response data and proposes the use of a Gaussian mixture model combined with the knowledge of dynamic characteristics modeled as probability distributions together with additional logic and appropriate thresholds in order to implement a real-time driver/vehicle response diagnostics system. Our efforts focus on the vehicle-following part of driving. The system is tested on a customized vehicle using different drivers under different driving conditions. We demonstrated that the system can distinguish between different drivers and can classify driver aggressiveness during vehicle following.

Cost-Optimal Charging of Plug-In Hybrid Electric Vehicles Under Time-Varying Electricity Price Signals

Saeid Bashash and Hosam K. Fathy

This paper develops a convex quadratic programming framework for the charge pattern optimization of plug-in hybrid electric vehicles (PHEVs) under time-varying electricity price signals. The work is motivated by the need for a computationally efficient PHEV charging and discharging model in bidirectional vehicle-to-grid (V2G) integration studies, accounting for the hybrid powertrain dynamics and battery energy losses of PHEVs. We use an equivalent circuit battery model to compute battery energy losses during grid charging and discharging and then derive the total fuel and electricity cost of the PHEV model as a quadratic function of battery state of charge and show the application of the proposed method in various V2G-related problems.

Task-Specific Performance Evaluation of UGVs: Case Studies at the IVFC

Wuling Huang, Ding Wen, Jason Geng, and Nanning Zheng

Performance evaluation is considered as an important part of the unmanned ground vehicle (UGV) development. This paper discusses a task-specific performance evaluation model of UGVs applied in the Intelligent Vehicle Future Challenge (IVFC) annual competitions. It is defined in functional levels with a formal evaluation process, including metrics analysis, metrics preprocessing, weights calculation, and TOPSIS and fuzzy comprehensive evaluation methods. IVFC 2012 is selected as a study case, and five UGVs overall performances are evaluated with specific analyzed autonomous driving tasks of environment perception, structural on-road driving, unstructured zone driving, and dynamic path planning. The model is proved to be helpful in IVFC serial competitions UGVs performance evaluation.

Automatic Detection of Squats in Railway Infrastructure

Maria Molodova, Zili Li, Alfredo Núñez, and Rolf Dollevoet

This paper presents an automatic method for detecting railway surface defects called "squats" using axle box acceleration (ABA) measurements on trains. The method is based on a series of research results from a group in the field of railway engineering, which includes numerical simulations, the design of the ABA prototype, real-life implementation, and extensive field tests. We enhanced the ABA signal by identifying the characteristic squat frequencies, using improved instrumentation for making measurements and using advanced signal processing. The automatic detection algorithm for squats is based on wavelet spectrum analysis and determines the squat locations. The method was validated on the Groningen–Assen track in The Netherlands and accurately detected moderate and severe squats with a hit rate of 100%, with no false alarms. The methodology is also sensitive to small rail surface defects and enables the detection of squats at their earliest stage. The hit rate for small rail surface defects was 78%.

Traffic Sign Recognition With Hinge Loss Trained Convolutional Neural Networks

Junqi Jin, Kun Fu, and Changshui Zhang

We describe the details of our model's architecture and suggest a hinge loss stochastic gradient descent (HLSGD) method to train convolutional neural networks (CNNs). Our CNN consists of three stages (70–110–180) with 1 162 284 trainable parameters. The HLSGD is evaluated on the German Traffic Sign Recognition Benchmark, which offers a faster and more stable convergence and state-of-the-art recognition rate of 99.65%. We write a graphics processing unit package to train several CNNs and establish the final classifier in an ensemble way.

Linear and Weakly Nonlinear Stability Analyses of Cooperative Car-Following Models

Julien Monteil, Romain Billot, Jacques Sau, and Nour-Eddin El Faouzi

This paper considers the impact of cooperative systems on traffic dynamics and, more precisely, on flow stability. Here, the effects of cooperative traffic are modeled through a general bilateral multianticipative car-following law that improves cooperative drivers' perception of their surrounding traffic conditions within a given communication range. To better understand what happens in unstable conditions, information on the shock wave structure is studied in the weakly nonlinear regime by using the reductive perturbation method. The shock wave equation is obtained for generic car-following models by deriving the Korteweg–de Vries equations. We then derive traffic-state-dependent conditions for the sign of the solitary-wave amplitude. This analytical result is verified through simulations. Simulation results confirm the validity of the speed estimate.

Bus Bridging Disruption in Rail Services With Frustrated and Impatient Passengers

Yibing Wang, Jingqiu Guo, Graham Currie, Avishai (Avi) Ceder, Wei Dong, and Brendan Pender

An unexpected disruption in a rail network can cause a significant degradation in the level of service. When a disruption occurs, it is crucial to provide quick and efficient substitution of services via alternative transportation modes. The amount of disruptions is surprisingly high; for example, more than 15 000 disruptions in six months in Melbourne, Australia. The provision of bus bridging services calls for proper planning and designing of a temporary bus bridging network considering limited bus and driver resources and prevailing urban traffic conditions. Among a number of tasks concerning bus bridging, the demand modeling of affected train passengers is a prerequisite for satisfactory bus bridging practice. This paper explores this demand modeling problem with a series of analytical results delivered. Large-scale Monte Carlo simulations were designed and implemented to demonstrate a range of mathematical conclusions.

Local Ramp Metering in the Presence of a Distant Downstream Bottleneck: Theoretical Analysis and Simulation Study

Yibing Wang

This paper addresses the local ramp metering problem in a downstream bottleneck case. Theoretical analysis indicates that the well-known feedback ramp metering algorithm ALINEA may lead to a poorly damped closed-loop behavior in this case, but PI-ALINEA, a suitable proportional–integral (PI) extension of ALINEA, can lead to satisfactory control performance. The stability of the closed-loop ramp metering system with PI-ALINEA is rigorously proved. Simulation studies are conducted using a macroscopic traffic flow model to demonstrate that the ramp metering performance of ALINEA indeed deteriorates in the distant downstream bottleneck case, whereas a significant improvement is obtained using PI-ALINEA. Moreover, with its control parameters appropriately tuned, PI-ALINEA is found to be universally applicable to a range of distances between the on-ramp and downstream bottlenecks. This indicates that little fine-tuning would be necessary in field applications.

Adaptive Bidirectional Platoon Control Using a Coupled Sliding Mode Control Method

Ji-Wook Kwon and Dongkyoung Chwa

This paper proposes an adaptive bidirectional platoon control method for an interconnected vehicular system using a coupled sliding mode control (CSMC) to improve the performance and stability of the bidirectional platoon control and guarantee the string stability. The previous works in the field of platoon control are based on two strategies: leader–predecessor strategy and bidirectional strategy. A platoon control law using a CSMC method is proposed for interconnected vehicular systems based on the bidirectional strategy such that the problems arising from communication devices in the previous works can be overcome. In particular, unlike the previous works using the bidirectional strategy, the proposed adaptive platoon control law can lead to the improved control performance of the whole system and guarantee the string stability.

ADCROSS: Adaptive Data Collection from Road Surveilling Sensors

Suchetana Chakraborty, Sandip Chakraborty, Sukumar Nandi, and Sushanta Karmakar

This paper introduces the concept of k-strip length coverage along the road that ensures a better sensing coverage for the detection of moving vehicles. To extend the network lifetime, every sensor follows a sleep–wake schedule maintaining the network connectivity and the k-strip length coverage. This scheduling problem is modeled as a graph optimization, the NP-hardness of which motivates designing a centralized heuristic, providing an approximate solution. As a sensor network is inherently distributed in nature, properties of the centralized heuristic are explored to design a per-node solution based on local information. Performance of the proposed scheme is analyzed through the simulation results.

Dynamic Probabilistic Drivability Maps for Lane Change and Merge Driver Assistance

Sayanan Sivaraman and Mohan Manubhai Trivedi

This study presents a novel probabilistic compact representation of the on-road environment, i.e., the dynamic probabilistic drivability map (DPDM), and demonstrates its utility for predictive lane change and merge (LCM) driver assistance during highway and urban driving. Using the DPDM, we develop a general predictive system for LCM. We formulate the LCM assistance system to solve for the minimum cost solution to merge or change lanes, efficiently solved using dynamic programming over the DPDM. Based on the DPDM, the LCM system recommends the required acceleration and timing to safely merge or change lanes with minimum cost. System performance has been extensively validated using real-world on-road data, including urban driving, on-ramp merges, and both dense and free-flow highway conditions.

Cooperative Bayesian Estimation of Vehicular Traffic in Large-Scale Networks

Alessandra Pascale, Monica Nicoli, and Umberto Spagnolini

This paper proposes an innovative stochastic method for vehicular traffic estimation based on a distributed reconstruction of the density field through the cooperation of smaller monitoring subnetworks. The method guarantees high accuracy and, at the same time, moderate computational cost (due to distributed processing). Moreover, subnetworks do not need to exchange sensitive information but simply traffic beliefs. We evaluate the performance of the method on simulated single-lane road scenarios, highlighting the potential benefits of the cooperative approach. As an example of application, the authors consider a fragmented monitoring scenario characterized by several sensor failures, and show how the proposed approach can overcome the problem related to the sensor malfunctions leveraging on information shared with neighboring subnetworks.

Multivehicle Cooperative Local Mapping: A Methodology Based on Occupancy Grid Map Merging

Hao Li, Manabu Tsukada, Fawzi Nashashibi, and Michel Parent

This paper introduces a method of occupancy grid map merging, dedicated to multivehicle cooperative local mapping in outdoor environments. In a general map merging framework, we propose an objective function based on occupancy

likelihood and provide some concrete procedures that are designed in the spirit of genetic algorithm to optimize the defined objective function. Based on the introduced method, we further describe a strategy of indirect vehicle-to-vehicle relative pose estimation, which can serve as a general solution for multivehicle perception association. We present a variety of experiments that validate the effectiveness of the proposed occupancy grid map merging method. We also demonstrate several useful application examples of the indirect vehicle-to-vehicle relative pose estimation strategy.

Autonomous Visual Navigation and Laser-Based Moving Obstacle Avoidance

Andrea Cherubini, Fabien Spindler, and François Chaumette

This paper validates a framework for avoiding moving obstacles during visual navigation with a wheeled mobile robot. Visual navigation consists in following a path, represented as an ordered set of key images, which have been acquired by an onboard camera in a teaching phase. While following such a path, our robot is able to avoid static and moving obstacles, which were not present during teaching, and which are sensed by an onboard lidar. The proposed approach explicitly takes into account obstacle velocities, estimated using an appropriate Kalman-based observer. The velocities are then used to predict the obstacle positions within a tentacle-based approach. Finally, our approach is validated in a series of real outdoor experiments, showing that when the obstacle velocities are considered, the robot behavior is safer, smoother, and faster than when they are not.

Growing Spatially Embedded Social Networks for Activity-Travel Analysis Based on Artificial Transportation Systems

Songhang Chen, Fenghua Zhu, and Jianping Cao

Social activity-travel has gained attention. To study its generation mechanism and behavioral characteristics, social network data are usually essential. However, due to individual privacy, it is rather difficult for traditional methods such as questionnaires to collect abundant reliable data. Therefore, we propose a novel method to grow realistic social networks based on artificial transportation systems (ATS). By incorporating the activity-travel simulation provided by ATS and a new agent-based model for social interaction, the method takes into account human mobility to generate spatially embedded social networks. A case study based on computational experiments is carried out to verify the method. The results indicate that the method can generate social networks with similar topological and spatial characteristics to real social networks.

Learning a Part-Based Pedestrian Detector in a Virtual World

Jiaolong Xu, David Vázquez, Antonio M. López, Javier Marín, and Daniel Ponsa

In this paper, an automatic view clustering and part alignment is first performed by using virtual-world pedestrians, i.e., human annotations are not required. Second, a mixture-of-parts approach that allows part sharing among different views is used. Third, these proposals are integrated in a learning framework that also allows incorporating real-world training data to perform domain adaptation between virtual- and real-world cameras. Overall, the obtained results on four popular onboard data sets show that our proposal clearly outperforms the state-of-the-art deformable part-based detector known as latent SVM.

Analysis of the Godunov-Based Hybrid Model for Ramp Metering and Robust Feedback Control Design

Pushkin Kachroo, Lillian Ratliff, and Shankar Sastry

This paper presents a detailed analysis of a Godunov-approximation-based dynamics model for an isolated traffic ramp metering problem. The model for the system is based on a Godunov numerical scheme so that the lumped parameter approximation retains the weak solution shock and rarefaction wave properties exhibited by the distributed model. The paper explicitly considers uncertainty in the system parameters and shows how to design controllers that are robust to those uncertainties. Simulations are performed to show the effectiveness of the proposed control law.

Challenges Toward Wireless Communications for High-Speed Railway

Bo Ai, Xiang Cheng, Thomas Kürner, Zhang-Dui Zhong, Guan Ke, Rui-Si He, Lei Xiong, David W. Matolak, David G. Michelson, and Cesar Briso-Rodriguez

We discuss in detail the main differences in research for wireless communications between the high-speed railway (HSR) operation scenarios and the conventional public land mobile scenarios. The latest research progress in wireless channel modeling in viaducts, cuttings, and tunnels scenarios is discussed. The characteristics of nonstationary, line-of-sight (LOS) sparse, and LOS multiple-input–multiple-output channels, which are the typical channels in HSR scenarios, are analyzed. Some novel concepts such as composite transportation and key challenging techniques such as train-to-train communication, vacuum maglev train techniques, the security for HSRs, the fifth-generation wireless communications related techniques for future HSR development for safer, more comfortable, and more secure HSR operation are also discussed.

Modeling Shuttle-Lane Roadwork Operated by Temporary Traffic Signals Using Microsimulation

Mohammed Alterawi and Saad Yousif

This paper presents a newly developed microsimulation model for shuttle-lane urban roadworks focusing on issues relating to temporary traffic signals (TTS) control and its effectiveness. The model deals with general and more specific drivers' behaviors. The main criteria of this model are governed by the application of car-following and shuttle-lane rules. The model has been calibrated and validated using real traffic data taken from observed urban shuttle lane roadwork sites for both fixed-time and vehicle-actuated TTS. Modified signal settings and various microwave vehicle detector detection ranges were also assessed in terms of their impact on capacity and delays.

The Exploitation of Vehicle-to-Grid Function for Power Quality Improvement in a Smart Grid

Morris Brenna, Federica Foiadelli, and Michela Longo

Smart grids can be a good challenge in the future if they are intelligently managed. Therefore, the exploitation of the energy resources distributed into the network is one of the most discussed themes in the actual scientific literature, together with the attention to be paid to the power quality improvement. This paper provides a possible solution to some common and

dangerous power quality problems, the voltage sags, considering the large diffusion of the electric vehicles. A deep energy and power analysis to evaluate the feasibility of the vehicle-to-grid function to compensate PQ disturbs is presented.

Probabilistic and Holistic Prediction of Vehicle States Using Sensor Fusion for Application to Integrated Vehicle Safety Systems

Beomjun Kim and Kyongsu Yi

This paper presents a probabilistic and holistic prediction algorithm for vehicle states using multisensor fusion with three concerns: reliable and reasonable information fusion, extension of predicted states, and real-time evaluation of prediction uncertainties. The main idea is that a state-prediction problem can be solved as a multistage optimal estimation problem based on the current vehicle motion, a road geometry description in the current body-fixed frame, a path-following behavior model, and the error covariance of each. The prediction algorithm consists of two sequential parts of estimation and prediction. It is shown that the state-prediction performance can be significantly enhanced by the proposed prediction algorithm compared with conventional methods.

Deep Architecture for Traffic Flow Prediction: Deep Belief Nets With Multitask Learning

Wenhao Huang, Guojie Song, Haikun Hong, and Kunqing Xie

This paper proposes a deep architecture that consists of a deep belief network on the bottom and a multitask regression layer on the top. To incorporate multitask learning into our deep architecture, a multitask regression layer is used above the deep belief network for supervised prediction. To make multitask learning more effective and take advantage of weight sharing in our deep architecture, we propose a grouping method based on weights in the top layer to make multitask learning more effective. Experiments on transportation data sets show good performance of our deep architecture. It is also presented that multitask learning can improve the generalization performance of shared tasks. Abundant experiments show that our approach achieved nearly 5% improvements over state-of-the-art approaches.

North Atlantic Aircraft Trajectory Optimization

Olga Rodionova, Mohamed Sbihi, Daniel Delahaye, and Marcel Mongeau

The North Atlantic oceanic airspace accommodates air traffic between North America and Europe. For conflict-free flight progress, the Organized Track System is established in the North Atlantic and flights are prescribed to follow predefined oceanic tracks. Aircraft often follow routes that are not optimal in view of their departure and destination points. Here, optimal conflict-free trajectories are constructed for several flight sets based on the new proposed separation standards, with respect to the flight input data and oceanic winds. This paper constructs two test problems based on real air-traffic data, and it presents very encouraging results of simulations for these data.

Data Dissemination in VANETs: A Scheduling Approach

Xia Shen, Xiang Cheng, Liuqing Yang, Rongqing Zhang, and Bingli Jiao

This paper designs a novel data dissemination strategy from the scheduling perspective. A data dissemination scheduling framework is then proposed, where the main challenge is how to assign the transmission opportunity to nodes with maximum dissemination utility and to avoid the collision problem. Proposed is a novel and practical relay selection strategy and adopt the space–time network coding with low detection complexity and space–time diversity gain to improve the dissemination efficiency. Compared with random access dissemination such as CodeOn-Basic and noncooperative transmission, our proposed data dissemination strategy performs better in terms of the dissemination delay. In addition, the proposed strategy works even better in the dense network than the sparse scenario, a sharp contrary of the CodeOn-Basic method.

Future Dual-Frequency GPS Navigation System for Intelligent Air Transportation Under Strong Ionospheric Scintillation

Jiwon Seo and Todd Walter

This paper investigates possible improvement in the availability of GPS-based aircraft landing guidance down to 200 ft above the runway, also known as localizer performance with vertical guidance (LPV)-200, under strong ionospheric scintillation when dual-frequency signals are available. Based on the availability study, this paper proposes and justifies a GPS aviation receiver performance standard mandating a fast reacquisition after a very brief signal outage due to scintillation. In order to support a temporary single-frequency operation under a single frequency loss due to scintillation, a new vertical protection level (VPL) equation is proposed and justified. With this new performance requirement and new VPL equation in place, 99% availability of LPV-200 would be attainable, rather than 50% at the current standards, even under the severe scintillation scenarios considered in this paper.

Vehicle-to-Vehicle Propagation Models With Large Vehicle Obstructions

Ruisi He, Andreas F. Molisch, Fredrik Tufvesson, Zhangdui Zhong, Bo Ai, and Tingting Zhang

In this paper, the authors present measurement results and model the propagation channel in which a bus acts either as a shadowing object or as a relay between two passenger cars. We analyze the influence of the bus location and car separation distance on the path loss, shadowing, small-scale fading, delay spread, and cross correlation. The main effect of the bus is that it is acting as an obstruction creating an additional 15- to 20-dB attenuation and an increase in the root-mean-square delay spread by roughly 100 ns. A Nakagami distribution is found to well describe the statistics of the small-scale fading, by using Akaike information criterion and the Kolmogorov–Smirnov test. The distance dependence of the path loss is analyzed and a stochastic model is developed.

Efficient Evaluation of Collisions and Costs on Grid Maps for Autonomous Vehicle Motion Planning

Georg Tanzmeister, Martin Friedl, Dirk Wollherr, and Martin Buss

This work gives theoretical and practical insights on how to efficiently check a large number of configurations for collision and cost and presents two efficient algorithms for their calculation: FAMOD, an approximate method based on convolution, which is independent of the size and the shape of the robot mask, and vHGW-360, an exact method based on the van Herk–Gil–Werman morphological dilation algorithm,

which can be used if the robot shape is rectangular. Both algorithms were implemented and evaluated on graphics hardware to demonstrate the applicability and benefit to real-time path and motion planning systems.

Coordinated Control of Wheeled Vehicles in the Presence of a Large Communication Delay Through a Potential Functional Approach

Haiyun Hu, Se Young Yoon, and Zongli Lin

This paper studies the flocking problem for a multiagent system, in which each agent is a vehicle with nonholonomic dynamics. In particular, we consider the case in which the agents are subjected to an arbitrarily large communication delay. A distributed low gain control law is derived based on the gradient of an artificial potential function. We demonstrate using the Lyapunov functional approach in which the proposed control law drives the multiagent system into the stable flocking behavior. The effectiveness of the proposed control law is verified in numerical simulation.

Mobile Traffic Sensor Routing in Dynamic Transportation Systems

Ning Zhu, Yang Liu, Shoufeng Ma, and Zhengbing He

The motion ability of traffic sensors is introduced to improve the performance of transportation network surveillance. A mobile traffic sensor routing problem is proposed, modeled as a novel vehicle routing problem. A measure of traffic information acquisition benefits is developed and used to gauge the surveillance performance. To solve this mobile sensor routing problem, a hybrid two-stage heuristic algorithm is designed, which is based on particle swarm optimization and ant colony optimization. Numerical experiments are conducted. The results show that the mobile traffic sensor has a better network surveillance performance than the fixed sensor in most experimental cases.

Intelligent Carpool Routing for Urban Ridesharing by Mining GPS Trajectories

Wen He, Kai Hwang, and Deyi Li

To support efficient carpooling service in heavy urban traffic, we propose an intelligent routing scheme based on mining GPS trajectories from shared riders. The carpooling system provides many-to-many services with multiple pickup and dropping points. To join a daily carpooling group, the riders must accept a compromised route that is efficient after merging preferred routes by all qualified riders. We developed three frequency-correlated algorithms for route mining, rider selection, and route merging in an urban carpool service. Our approach can cope with the traffic dynamics to yield a suboptimal shared route. Our scheme was successfully tested under heavy Beijing traffic over hundreds of riders. We developed performance metrics to measure the service cost and mileage saved. The ultimate goal is to minimize the riding distances and the transportation costs, and thus alleviate the urban traffic jams.

Stochastic Analysis of a Single-Hop Communication Link in Vehicular Ad Hoc Networks

Khadige Abboud and Weihua Zhuang

A vehicular *ad hoc* network (VANET) is a promising addition to intelligent transportation systems. This paper presents a probabilistic analysis of the communication link in vehicular ad hoc networks for three vehicle density ranges. First, the stationary distribution of the communication link length using mesoscopic mobility models is presented. Second, a stochastic microscopic mobility model that captures time variations of intervehicle distances (distance headways) is proposed. A discrete-time finite-state Markov chain with state-dependent transition probabilities is proposed to model the distance headway. Third, the proposed stochastic microscopic model and the first passage time analysis are used to derive the probability distribution of the communication link lifetime. Numerical results are presented to evaluate the proposed model, which demonstrate a close agreement between analytical and simulation results.

Yaw Estimation Using Cylindrical and Ellipsoidal Face Models

A. Narayanan, R. M. Kaimal, and K. Bijlani

Accurate head yaw estimation is necessary for detecting driver inattention in forward collision warning systems. In this paper, the authors propose three geometric models under the ellipsoidal framework for accurate head yaw estimation and present theoretical analysis of the cylindrical and ellipsoidal face models used for yaw angle estimation of head rotation. The relationship between cylindrical, ellipsoidal, and the proposed models is derived. We provide error functions for all models. Furthermore, for each model, overestimation/underestimation of angle, zero crossings of error, bounds on yaw angle estimate, and bounds on error are presented. Experimental results of the proposed models on four standard head pose data sets yielded a mean absolute error between 4° and 8°, demonstrating the efficacy of the proposed models over the state-of-the-art methods.

An Efficient Visibility Enhancement Algorithm for Road Scenes Captured by Intelligent Transportation Systems

Shih-Chia Huang, Bo-Hao Chen, and Yi-Jui Cheng

The visibility of images of outdoor road scenes will generally become degraded when captured during inclement weather conditions. Drivers often turn on the headlights of their vehicles and streetlights are often activated, resulting in localized light sources in images capturing road scenes in these conditions. Additionally, sandstorms are also weather events that can be encountered when driving. In sandstorms, atmospheric sand has a propensity to irregularly absorb specific portions of the spectrum, thereby causing color-shift problems in the captured image. This paper presents a novel and effective haze removal approach to remedy problems caused by localized light sources and color shifts. Experimental results demonstrate that the proposed haze removal technique can recover scene radiance more effectively while demanding less computational cost than traditional state-of-the-art haze removal techniques.

Realization of a Dilemma-Zone Guiding Algorithm at Signalized Intersections

Dong Yang, Hongfei Jia, and Ming Tang

This paper presents a dilemma-zone (DZ) avoidance guiding system for vehicles approaching the intersection. The purpose of the system is to assist drivers in determining the driving behavior and prevent vehicles from being caught in a DZ at the onset of yellow. The optimal driving behavior is determined through warning information or detailed guiding strategy. To

calculate the guiding strategies, a DZ guiding algorithm is proposed with a special focus on vehicle DZ state and interaction between vehicles. A simulation-based study proved the function of the proposed system and the effectiveness of the algorithm. It is found that, based on the conditions of driver's comfort and car-following safety, guiding system can provide proper guidance for vehicles and determine the optimal driving behavior in advance.

Vehicle Color Recognition on Urban Road by Feature Context

Pan Chen, Xiang Bai, and Wenyu Liu

Vehicle information recognition is a key component of intelligent transportation systems. Color plays an important role in vehicle identification. As a vehicle has its inner structure, the main challenge of vehicle color recognition is to select the region of interest (ROI) for recognizing its dominant color. In this paper, the authors propose a method to implicitly select the ROI for color recognition. Preprocessing is performed to overcome the influence of image quality degradation. Then, the ROI in vehicle images is selected by assigning the subregions with different weights, which are learned by a classifier trained on the vehicle images. We train the classifier by linear support vector machine for its efficiency and high precision. The experiments are extensively validated on both images and videos, which are collected on urban roads. The proposed method outperforms other competing color recognition methods.

Magnetometer Calibration for Portable Navigation Devices in Vehicles Using a Fast and Autonomous Technique

Ahmed Wahdan, Jacques Georgy, Walid F. Abdelfatah, and Aboelmagd Noureldin

This paper proposes a fast and automatic magnetometer calibration that requires small space coverage. The proposed technique performs 3-D-space magnetometer calibration using 2-D calibration equations with pitch and roll sectors. The 3-D space is divided into groups of pitch and roll sectors. Inside each sector, 2-D calibration can be performed for the leveled magnetometer readings, which makes the calibration process faster and requires less data. Pseudo-tethered navigation devices are tethered at normal operation, but they can change their orientation according to user needs such as portable vehicle navigation devices, which can be placed on the dashboard of a vehicle or attached to the wind shield.

Computational Transportation and Transportation 5.0

For the past few days, I have spent most of my free time reading and thinking about a book entitled ***INDUSTRIE 4.0***, put together by a few German experts; the book is a follow-up to ***Recommendations for Implementing the Strategic Initiative INDUSTRIE 4.0***, the final report of the **Industrie 4.0 Working Group**, published earlier last year as an effort to secure the future of German manufacturing. I received the book in July as a gift from SIEMENS China after my lecture on ACP-Based Smart Parallel Management of Intelligent Enterprises at the SIEMENS Industrial Forum for Future Manufacturing. To be frank, I was quite disappointed with the book's content—it did not cover or explore much new ground academically—and was very surprised by the lavish praise it has received so far from the media and so-called experts. I am really not sure whether those experts had actually read the publication or if they were knowledgeable about the field. Many of the ideas and suggestions outlined in the original ***INDUSTRIE 4.0*** have been published in ***Advanced Manufacturing Technology in China: A Roadmap to 2050***, for which I was one of the coeditors. Written in 2007 and made public in 2009 as one of 18 volumes in **Science & Technology in China: A Roadmap to 2050**, I had the opportunity to be a part of the project as a leading organizer and contributor. In my reading, the key point of the entire book can be distilled in a passage found in the beginning of Chapter 7 by Anton S. Huber of SIEMENS: "...this can be understood as inside the inner part of an enterprise, there exists a parallel digital enterprise." This is an idea I have long championed—if I have more time, I would like to write a review article titled ***INDUSTRIE 4.0—Queen's New Clothes***.

Reading the book brought back some old memories from my early research career and inspired some new thoughts on the future of transportation research. I started my official research career in fracture mechanics (yes, I did have an "unofficial" research career before that) and then moved into computational mechanics. I left the field of computational mechanics after one particular experience: it had taken me an entire month to locate a single bug in my Fortran program. In the middle of thousands of lines, there was one highly unfortunate typo—the letter "l" replaced with the with number "1" in a variable name! Note that only very primitive line debugging tools were available in the early 1980s, instead of graphic-based interactive integrated debugging environments today. As educational as the month-long experience was, I was left depressed at thoughts of what I could have done with that month—better used for reading and writing instead of looking for such a ridiculous and meaningless bug among lines and lines of codes. However, my failure attempt at computational mechanics left me with a strange but strong complexity with fields that started with the term "computational." This might be what led me to coin the terms "computational sociology" and "computational social studies," what led to research in my social computing and computational societies over a decade ago. I am glad that those fields have emerged as major new directions around the world today. Now, I think it is time to promote the field of ***Computational Transportation*** as a research direction to integrate and lift the current work in computer simulation and computational analysis of transportation systems to a new and higher ground, where powerful new computing methods, advanced sensing techniques, and big data in cyber, physical, and social spaces can be easily utilized—much like what has happened in computational mechanics, computational fluid dynamics, computational physics, computational chemistry, computational social studies, and many other computational X. I am glad to see a few conferences and educational programs on Computational Transportation Science (CTS) have emerged over the past few years, and the University of Illinois at Chicago has even started a Ph.D. program in CTS.

From Computational Transportation, we can leap to ***Transportation 5.0***! Why? I will not discuss the definition of Transportation 1.0 to 3.0, but Cyber-Physical Systems (CPS)

has been claimed to be the foundation of ***INDUSTRIE 4.0***. Transportation is a direct result of human and social activities; thus, we must have social component explicitly represented in transportation research and development. Therefore, my vision of the next generation of intelligent transportation systems must be based on Cyber-Physical-Social Systems (CPSS), a step beyond CPS and, thus, ***INDUSTRIE 4.0***, consequently, Transportation 5.0. Yes, currently, we are still in the early stage of CPS-based Transportation 4.0, as witnessed from connected vehicles to electrified infrastructure.

As a veteran in real-time embedded systems, I was excited to see the emergence of CPS a decade ago as the next generation of networked embedded systems, with focus shifted from hardware to software. In 2008, as the Associate Editor-in-Chief of ***IEEE Intelligent Systems***, I proposed to launch a new department called CPS Department and promised to write the first article for its inaugural issue. However, I felt the coming of real-time social signals, mainly from my own blogging experience, thus the need to add social dimension to embedded applications. After becoming the magazine's Editor-in-Chief in 2009, I decided to change the name of the department from CPS to CPSS and started the first issue in 2010 with my article "The Emergence of Intelligent Enterprises: From CPS to CPSS," which overlapped ***INDUSTRIE 4.0*** significantly in key ideas, technical processes, and system architectures, but with explicit and fundamental considerations for connected and real-time social and human aspects. Now, with Facebook, Twitter, Weibo, and, in particular, Wechet, real-time social signals, particularly real-time social signals for transportation (so-called ***social transportation***), are pervasive and easily usable. I have seen some emerging revolutions in China: taxi drivers in metropolitan Beijing have become connected human (not a program or an algorithm) optimizer, constantly thinking, calculating, and optimizing their routes, actions, and profits based on real-time social signals received from smartphones and onboard cab-sharing information systems, social signal-based public transportation systems in Chongqing and other cities, and, of course, the significant behavior changes in ordinary citizens when they are calling a cab or taking a bus (a senior citizen, who can be less savvy with smartphones, finds that it is difficult to hail a taxi on the street now, a problem we need to address soon). There are even more dramatic changes to come if all cars are as connected and roads as electrified as mobile phones and distributed energy traders and storage devices are now, as outlined in our whitepaper "Electrified Vehicles and the Smart Grid: The ITS Perspective" (see vol. 15, no. 4, pp. 1388–1404).

It is my belief that ***CPSS-based Transportation 5.0***, more specifically, software-defined transportation systems, O2O (online to offline and vice verse) computational transportation experiments, and parallel transportation with knowledge automation for closed-loop control and management with society-wide feedback, will be realized for real-world application before we have the ability to know and see what an actual CPS-based Transportation 4.0 system is.

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