Scanning the Issue

A Data-Driven Air Traffic Sequencing Model Based on Pairwise Preference Learning

S. Jung, S. Hong, and K. Lee

This paper proposes a new framework for predicting arrival sequences of aircraft based on a preference learning approach that emulates the sequencing strategies of human air traffic controllers by learning from historical data. The proposed algorithm works in two stages: it first learns the probabilistic preferences between each pair of arriving aircraft, and the overall sequence for a new set of aircraft is then determined by combining the pairwise probabilities. The proposed model is validated using historical traffic data at Incheon International Airport, and its performance is evaluated using Spearman's rank correlation and dynamic simulation analysis. A possible application for the proposed method in decision support for arrival sequencing is also suggested.

Improving Viability of Electric Taxis by Taxi Service Strategy Optimization: A Big Data Study of New York City

C.-M. Tseng, S. C.-K. Chau, and X. Liu

Electrification of transportation is critical to a low-carbon society. In particular, public vehicles (e.g., taxis) provide a crucial opportunity for electrification. Despite the benefits of eco-friendliness and energy efficiency, adoption of electric taxis faces several obstacles, including constrained driving range, long recharging duration, limited charging stations, and low gas price, all of which impede taxi drivers' decisions to switch to electric taxis. On the other hand, the popularity of ride-hailing mobile apps facilitates the computerization and optimization of taxi service strategies, which can provide computer-assisted decisions of navigation and roaming for taxi drivers to locate potential customers. This paper examines the viability of electric taxis with the assistance of taxi service strategy optimization, in comparison with conventional taxis with internal combustion engines. A big data study is provided using a large data set of real-world taxi trips in New York City (NYC). The author's methodology is to first model the computerized taxi service strategy by Markov decision process, and then obtain the optimized taxi service strategy based on the NYC taxi trip data set. The profitability of electric taxi drivers is studied empirically under various battery capacity and charging conditions. Consequently, they shed light on the solutions that can improve the viability of electric taxis.

Empirical Observations and Formulations of Tri-Class Traffic Flow Properties for Design of Traffic Signals

C.-L. Lan and G.-L. Chang

Empirical observations on the mixed traffic flow, consisting of scooters (motorcycles), passenger cars, and buses, using drone video is presented in this paper. To capture the complex interactions among different types of vehicles on an urban arterial, a mesoscopic vehicle-packet concept is proposed to formulate such traffic flows. Extensive investigations with both field-data evaluations and numerical analyses have confirmed the applicability of the purposed model to serve as the basis for developing mesoscopic tri-class flow simulation models or for designing signals for arterials plagued by such mixed flows.

State Estimation for Communication-Based Train Control Systems With CSMA Protocol

L. Zou, T. Wen, Z. Wang, L. Chen, and C. Roberts

This paper is concerned with the train positioning problem for communication-based train control systems (CBTCs) with carrier-sense multiple access (CSMA) protocol scheduling based on a state estimation method. First, the dynamics of a train with multiple cars are modeled by a set of Newton's motion equations. A Bernoulli distributed sequence is adopted to characterize the transmission behaviors of the p-persistent CSMA protocol. Then, in order to achieve satisfactory estimation accuracy, sufficient conditions are derived to ensure that the estimation error is ultimately bounded in mean square. Two different state estimation algorithms concerning different performance requirements are designed based on the stochastic analysis technology and linear matrix inequalities. Finally, a simulation example is given to demonstrate the effectiveness of the developed state estimation algorithms.

Discovering Frequent Movement Paths From Taxi Trajectory Data Using Spatially Embedded Networks and Association Rules

W. Yu

Similar to the role of ocean circulation in a marine system, identifying the frequent paths and cycles of the travel flows within a city would be critical to understanding the principles behind the travel flow surfaces. This paper proposes a multi-level method for the discovery of movement paths by incorporating the techniques of network analysis and association rules. The experimental results show that the method is effective for the application of mining taxi trajectory data.

Integrated Production Inventory Routing Planning for Intelligent Food Logistics Systems

Y. Li, F. Chu, C. Feng, C. Chu, and M. Zhou

An intelligent logistics system is an important branch of intelligent transportation systems. Its high efficiency can significantly reduce food waste, improve food quality and safety, and enhance the competitiveness of food companies. In this paper, the authors investigate a new integrated planning problem for intelligent food logistics systems. Two objectives

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are considered: minimizing the total production, inventory, and transportation cost and maximizing the average food quality. For the problem, a bi-objective mixed integer linear programming model is formulated first. Then, a new method is developed to solve it. The computational results on a case study and on 185 randomly generated instances with up to 100 retailers and 12 periods show the effectiveness and efficiency of the proposed method.

Deep Spatio-Temporal Representation for Detection of Road Accidents Using Stacked Autoencoder

D. Singh and C. K. Mohan

A highly desirable but challenging problem of vision-based road accidents in the traffic surveillance video is addressed. The author's proposed framework automatically learns feature representation from the spatiotemporal volumes of raw pixel intensity instead of the traditional hand-crafted features. Since the accidents of vehicles are considered as unusual incidents, they extract deep representation using denoising autoencoders trained over the normal traffic videos. The possibility of an accident is determined based on the reconstruction error and the likelihood of the deep representation. For the likelihood of the deep representation, an unsupervised model is trained using one class support vector machine. Also, the intersection points of the vehicle's trajectories are used to reduce the false alarm rate and increase the reliability of the overall system. The experiments on real accident videos collected from the CCTV surveillance network of Hyderabad City in India demonstrate the efficacy of the proposed approach.

Negotiation Between Vehicles and Pedestrians for the Right of Way at Intersections

S. Gupta, M. Vasardani, and S. Winter

A vehicle–pedestrian negotiation model is proposed describing the processing and exchange of negotiation cues among pedestrians and future self-driving vehicles, in order to speed up the traffic flow. The motion strategy for the vehicle approaching the pedestrian is formulated in order to negotiate its best chance to pass first, a process that closely mimics the common scenarios of everyday negotiation on roads. The simulation results show an improvement in the overall travel time of the vehicles as compared with the current best practice behavior (always stop) of the self-driving vehicles. The cost-benefit analysis of negotiation among both parties is also discussed in this paper.

A Similitude Theory for Modeling Traffic Flow Dynamics

X. Di, Y. Zhao, S. Huang, and H. X. Liu

Similitude theory, in particular, dimension analysis, is a common tool for testing scaled-down engineering models and is widely used in vehicle dynamics and other engineering fields. However, it is barely employed in scaling traffic flow dynamics. In this paper, dimension analysis is adapted to scale car-following dynamics. Under the guidance of the similitude theory, a scaled-down vehicle test bed is built to simulate stop-and-go traffic when there is no physical bottleneck present. The design of this testbed can be used to simulate traffic dynamics with automated vehicles and will pave the way for scaled-down connected and automated vehicle systems development.

Information-Driven Autonomous Intersection Control via Incentive Compatible Mechanisms

M. O. Sayin, C.-W. Lin, S. Shiraishi, J. Shen, and T. Başar

A new information-driven intersection control is proposed to enhance the quality of transportation by using communication between vehicles and roadside units. Congestions at intersections can have a different impact on different drivers, and yet such an impact cannot be measured by sensors. Furthermore, such information is driver-exclusive, i.e., not verifiable easily, and therefore prone to be misreported strategically. A strategy-proof intersection management is proposed to address such issues via a payment-based incentive compatible mechanism. This approach, based on the Vickrey-Clarke-Groove mechanism, guarantees truthful utility reporting by the vehicles, and correspondingly, maximizes the social welfare. The proposed scheme is universal such that it can be implemented based on various utility functions or intersection control constraints. A practical implementation is provided to analyze the performance via numerical simulations.

Hybrid Online Safety Observer for CTCS-3 Train Control System On-Board Equipment

Y. Zhang, H. Wang, T. Yuan, J. Lv, and T. Xu

Conventional over-speed protection methods of Chinese Train Control System-3 (CTCS-3) on-board equipment monitor the speed at discrete time instants. However, the over-speed behavior between discrete time instants cannot be detected, which may cause potential risks. To address this problem, the authors propose a hybrid safety observation method to monitor train speed during operation. Train behavior is modeled with hybrid automata, which takes parameters affecting train movement into consideration. Train behavior in the next control cycles is predicted periodically by computing the reachable set of the model. The safety property set is obtained according to the runtime speed limits. The intersection check between the reachable set and safety property set is performed to decide whether train speed may exceed the speed limit in a short future period. The results of a case study show that the observation method is feasible in verifying the violations of CTCS-3 on-board equipment safety properties.

A Hybrid Model for Short-Term Traffic Volume Prediction in Massive Transportation Systems

Z. Diao, D. Zhang, X. Wang, K. Xie, S. He, X. Lu, and Y. Li

A novel hybrid (DTMGP) model is presented to accurately forecast the volume of passenger flows multi-step ahead with the comprehensive consideration of factors from temporal, origin–destination spatial, and frequency and self-similarity perspectives. This model first applies discrete wavelet transform to decompose the traffic volume series into an appropriation component and several detailed components. Then, a more efficient tracking model is proposed to forecast the

appropriation component. A novel Gaussian Process model is proposed to forecast the detailed components. Experimental results show the effectiveness of the proposed hybrid model.

A Binary Borg-Based Heuristic Method for Solving a Multi-Objective Lock and Transshipment Co-Scheduling Problem

B. Ji, X. Yuan, and Y. Yuan

A bi-objective optimization model of the lock and transshipment co-scheduling problem (LTCP) is developed, where the delay time of ships at a dam and the extra cost of transshipment are considered as two parallel optimization objectives. A binary Borg (B-Borg) multi-objective evolutionary algorithm is proposed to combine with two heuristics (an adaptive large neighborhood search and a multi-order best fit strategy) to solve the LTCP. A large number of instances are generated by extracting from the historical data at the Three Gorges Dam, the simulation results of which show the effectiveness of the proposed model and the B-Borg-based hybrid solution algorithm.

Path Planning and Cooperative Control for Automated Vehicle Platoon Using Hybrid Automata

Z. Huang, D. Chu, C. Wu, and Y. He

Cooperative driving systems may increase the utilization of road infrastructure resources through coordinated control and platooning of individual vehicles with the potential of enhancing both traffic safety and efficiency. Vehicle cooperative driving is essentially a hybrid system that is a combination of discrete events, i.e., the transition of discrete cooperative maneuvering modes, such as vehicle merging and platoon splitting, as well as continuous vehicle dynamics. In this paper, a novel hybrid system consisting of the discrete cooperative maneuver switch and the continuous vehicle motion control is introduced into a multi-vehicle cooperative control system with a distributed control structure, leading each automated vehicle to conduct path planning and motion control separately.

Real-Time Traffic Sign Recognition Based on Efficient CNNs in the Wild

J. Li and Z. Wang

Both unmanned vehicles and driver assistance systems require solving the problem of traffic sign recognition with high accuracy and at high speed under various conditions. In this paper, the authors have designed and implemented a detector by adopting the framework of a faster R-convolutional neural network (CNN) and the structure of MobileNet. Here, color and shape information have been used to refine the localizations of small traffic signs, which are not easy to regress precisely. Finally, an efficient CNN with asymmetric kernels is used to be the classifier of traffic signs. Both the detector and the classifier have been trained on challenging public benchmarks. The results show that the proposed detector can detect all categories of traffic signs. The detector and the classifier proposed here are proved to be superior to the state-of-the-art.

Measurement-Based Markov Modeling for Multi-Link Channels in Railway Communication Systems

B. Zhang, Z. Zhong, R. He, G. Dahman, J. Ding, S. Lin, B. Ai, and M. Yang

Extensive multi-link wideband measurements in a viaduct railway environment at 460 MHz with two base stations and one mobile station are performed. Large-scale parameters (LSPs), including large-scale fading, Ricean K-factor, delay spread, and angle spread, are extracted from the measurement data. Based on the measurements, auto- and cross-correlation properties of each LSP are investigated. A Markov-based multi-link tapped-delay-line model for railway communications is established, where the Markov chains are introduced to model the birth and death state of multipath components in multi-link scenarios. The proposed channel model is implemented and validated with measurements.

Impact of Data Loss for Prediction of Traffic Flow on an Urban Road Using Neural Networks

T. Pamuła

Gathering real traffic data from the road network and predicting the evolution of traffic parameters, in many cases is based on incomplete or false data from vehicle detectors. Traffic flows in the network follow spatiotemporal patterns and this characteristic is used to suppress the impact of missing or erroneous data. A spatiotemporal prediction model based on neural networks is proposed. Multilayer perceptrons and deep learning networks (DLNs) with autoencoders are used. Prediction sensitivity to false data is estimated using traffic data from an urban traffic network. The prediction model based on DLN with autoencoders outperforms all others when one or more vehicle detectors fail.

SINet: A Scale-Insensitive Convolutional Neural Network for Fast Vehicle Detection

X. Hu, X. Xu, Y. Xiao, H. Chen, S. He, J. Qin, and P.-A. Heng

This paper presents a scale-insensitive convolutional neural network (SINet) for fast detecting vehicles with a large variance of scales. First, the authors present a context-aware RoI pooling to maintain the contextual information and original structure of small-scale objects. Second, they present a multi-branch decision network to minimize the intra-class distance of features. These lightweight techniques bring zero extra time complexity but prominent detection accuracy improvement. Their SINet achieves state-of-the-art performance in terms of accuracy and speed on the KITTI benchmark and a new highway data set, which contains a large variance of scales and extremely small objects.

Simulation of the Bluetooth Inquiry Process for Application in Transportation Engineering

A. Z. Masouleh and B. R. Hellinga

In this paper, the authors propose a simulation framework for Bluetooth inquiry process. This framework that considers

multiple inquiry scans and the effect of distance from the detector on the inquiry process. The simulation model was calibrated and validated using field data collected from two custom-built Bluetooth detectors. The simulation framework has been made into a simulation software tool entitled BlueSynthesizer, which can be combined with commercially available traffic microsimulation models to evaluate the use of Bluetooth technology within advanced traffic management systems.

Extracting Significant Mobile Phone Interaction Patterns Based on Community Structures

M. Ghahramani, M. Zhou, and C. T. Hon

Given the associated interrelated features of call-detail records in a region, can the authors find reasonably good clusters corresponding to human communities in a reasonably fast way? This paper answers this question by developing some related concepts and an efficient geospatial algorithm. Spatial constrains together with an optimal level of hierarchy are proposed in this partitioning algorithm to achieve an efficient hierarchy of geographical communities. By identifying key objects and their close associates, and exploring their communication patterns, they can detect shared interests and dominant interactions that influence societal patterns. Understanding such insight is essential for resource optimization in network planning, content distribution, and urban planning.

Linear Holding for Airspace Flow Programs: A Case Study on Delay Absorption and Recovery

Y. Xu and X. Prats

This paper presents a method to introduce linear holding to flights affected by the airspace flow program (AFP) initiatives. Trajectories are optimized at their planning stage in such a way that the program performance is improved in terms of delay absorption before the congested area, and delay recovery at the destination airport. This recovery process is studied by comparing the case where the same fuel consumption is fixed as the nominal flight, with several cases where some extra fuel allowances are considered at the flight planning stage. The results suggest that using the proposed method could partially recover part of the AFP delay, even with no extra fuel allowances. When extra fuel is allowed, however, the maximum delay recovery further increases, which also proves more cost-efficient than current operations, when flight speed is increased after experiencing all delay on ground.

Mathematical Models for Air Traffic Conflict and Collision Probability Estimation

M. Mitici and H. A. P. Blom

Increasing traffic demands and technological developments provide novel design opportunities for future air traffic management (ATM). To evaluate current air traffic operations and future designs, over the past decades, several mathematical models have been proposed for air traffic conflict and collision probability estimation. However, a few evaluations of these models with respect to their mathematical core exist. The aim of this paper is: 1) to present the mathematical core of the existing approaches for air traffic conflict and collision probability estimation using the same body of notations and definitions; 2) to outline the advances in estimating the probability of air traffic conflict and collision using a unified mathematical framework; 3) to outline various air traffic applications and their use of directed mathematical models for air traffic conflict and collision probability estimation; and 4) to provide insight into the capabilities and restrictions of the mathematical models in the evaluation of future ATM designs.

Automatic Vacant Parking Places Management System Using Multicamera Vehicle Detection

R. M. Nieto, Á. García-Martín, A. G. Hauptmann, and J. M. Martínez

This paper presents a multicamera system for vehicles detection and their corresponding mapping into the parking spots of a parking lot. The proposed system has been designed for realistic scenarios considering different cases of occlusion, illumination changes, and different climatic conditions; a real scenario (the International Pittsburgh Airport parking lot) has been targeted with the condition that existing parking security cameras can be used, avoiding the deployment of new cameras or other sensors infrastructures. The system is based on existing video object detectors and different proposed postprocessing stages.

Influence of Driving Behaviors on the Stability in Car Following

Y. Wang, J. Zhang, and G. Lu

Influence of the accepted risk level, response time, and sensitivity factor on the traffic flow is investigated via the desired safety margin (DSM) model. The stability criterion of the simplified DSM model is derived via linear stability theory. The numerical simulations show that the lower limit of the DSM influences traffic flow more significantly than the upper limit of the DSM, and that the increase in deceleration sensitivity has a more important influence on the stability of traffic flow than the increase in acceleration sensitivity. The results can provide reasonable values of driving behavior parameters for the stability of the primitive DSM model using the simplified DSM model. System stability can be maintained by adjusting the acceleration and deceleration control parameters, increasing DSM, or decreasing response time for the adaptive cruise control or vehicular platoon control system.

Analytic System to Evaluate Efficient Driving Programs in Professional Fleets

L. Pozueco, A. G. Tuero, A. G. Pañeda, X. G. Pañeda, D. Melendi, R. García, G. Díaz Orueta, and A. Rionda

An analytic system to evaluate the individual driver's progression in efficient driving is proposed. The system is based on the detection of efficient and inefficient behavioral patterns. Driving patterns are extracted from data collected every 1.5 s from the vehicles. Results of this applied research on the eco-driving field show that the proposed system identifies efficient

and inefficient actions that are used to fairly evaluate the drivers' performance.

An On-Line Optimal Controller for a Commuter Train

D. Yazhemsky, M. Rashid, and S. Sirouspour

This paper presents an optimal controller with mixed energy-time objective for commuter trains. The control problem is formulated as a convex second-order cone optimization, which can be solved numerically in real-time on an embedded computer. The problem formulation incorporates realistic train and trip models, including speed limits, track grade profiles, and traction and braking constraints. Numerical simulations demonstrate the effectiveness of the methodology.

Toward End-to-End Car License Plate Detection and Recognition With Deep Neural Networks

H. Li, P. Wang, and C. Shen

In this paper, the authors tackle the problem of car license plate detection and recognition in natural scene images. They propose a unified deep neural network, which can localize license plates and recognize the letters simultaneously in a single forward pass. The whole network can be trained end-to-end. In contrast to existing approaches which take license plate detection and recognition as two separate tasks and settle them step by step, their method jointly solves these two tasks by a single network. It not only avoids intermediate error accumulation but also accelerates the processing speed. For performance evaluation, four data sets including images captured from various scenes under different conditions are tested. Extensive experiments show the effectiveness and efficiency of their proposed approach.

Energy Aware Driving: Optimal Electric Vehicle Speed Profiles for Sustainability in Transportation

Z. Yi and P. H. Bauer

Optimization models for both, minimum transportation energy with travel time constraints and minimum travel time with transportation energy constraints are introduced. The resulting speed profiles are analyzed based on the fact that weather dependent speed profiles can save energy for electric transportation systems. Infinite dimensional optimization models are proposed for exact problem descriptions and approximate discretized convex models are derived for highly efficient solutions. The optimization tasks are formulated as a deterministic as well as a robust optimization problem, where weather conditions such as wind speed and rolling resistance effects are assumed to be known exactly or within uncertainty bounds. Simulations illustrate the utility of the proposed optimization models and demonstrate achievable efficiency improvements.

Vehicle Scheduling of Single Line Bus Service Using Operational Strategies

C. Tang, A. Ceder, S. Zhao, and Y.-E. Ge

This paper proposes a methodology to reduce the required number of public transport vehicles using operational strategies including limited stop, short turn, deadheading, and mixed strategies. This proposed methodology is based on a graphical human–machine interactive technique, called deficit function (DF). The DF allows schedulers to select a variable trip schedule for reducing the number of vehicles using optimal determination of the best-applied strategies. The process of adjusting variable trips to accommodate different strategies may result in passenger travel time changes. Two optimization models are developed to minimize these changes and determine a set of stops served by the variable trip schedule. This proposed methodology has been applied to a detailed example and a case study in Paris, France. The results show that the adjustment of a few trips to use certain strategies can reduce the number of buses required by three.

DOCTraMS: A Decentralized and Offline Community-Based Traffic Monitoring System

T. T. de Almeida, J. A. M. Nacif, F. P. Bhering, and J. G. R. Júnior

The high number of accidents and traffic jams negatively impact economy, environment, and health. Traditional monitoring systems require high installation and maintenance costs, and are dependent on a central element. Decentralized infrastructure has emerged as an attractive option; however, these systems cannot guarantee the synchronization between the devices' clocks. This paper presents DOCTraMS, a system that monitors and disseminates traffic conditions using a decentralized infrastructure. On-board units and roadside units exchange information to update their tables that describe the traffic conditions of each road segment. To validate DOCTraMS, the authors have implemented a real IEEE 802.11 b/g prototype at Rio de Janeiro, Brazil. Moreover, they have simulated larger scenarios using NS-3 with traffic data from São Paulo, Brazil. The system accuracy is higher than 90% in all scenarios.

Height-Finding for Automotive THz Radars

S. Shishanov, A. Bystrov, E. G. Hoare, A. Stove, M. Gashinova, M. Cherniakov, T.-Y. Tran, and N. Clarke

This paper explores radar methods to measure the coordinates (distance and height) of objects on or beside a road. It is shown that the height is best found by trilateration from sensors at multiple locations on a vehicle. The expressions obtained allow calculation of the coordinates of targets using a number of different methods of radar trilateration. The analysis was verified using an experimental system based on a 300-GHz ultra-wideband radar. The experimental results are in good agreement with the theoretical calculations; they confirmed the practicality of obtaining high-accuracy height measurements on distributed targets such as pedestrians. The physical basis of the techniques developed would also allow the plan position of a target to be found using the same approach.

A Comprehensive Study of the Effect of Spatial Resolution and Color of Digital Images on Vehicle Classification

K. F. Hussain, M. Afifi, and G. Moussa

Dimension and color are two important characteristics of any digital image that affect the cost of the digital camera used in image acquisition. In this paper, the authors

present a comprehensive study of the effect of these two characteristics on the vehicle classification process in terms of accuracy and performance. After performing more than 46 000 individual experiments using state-of-the-art CNNs and handcrafted features-based methods, they found that there is no significant influence of both color and spatial resolutions of the vehicle images on the classification results obtained by most state-of-the-art image classification methods. However, there is a correlation between the spatial resolution and the processing time required by most image classification methods. Their findings can play an important role in saving not only money but also time for vehicle type classification systems.

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