Scanning the Issue

Crowd Density Estimation Using Fusion of Multi-Layer Features

X. Ding, F. He, Z. Lin, Y. Wang, H. Guo, and Y. Huang

Crowd counting is very important in many tasks such as video surveillance, traffic monitoring, public security, and urban planning. However, achieving an accurate crowd counting and generating a precise density map are still challenging tasks due to occlusion, perspective distortion, complex backgrounds, and varying scales. In addition, most of the existing methods focus only on the accuracy of crowd counting without considering the correctness of a density distribution, namely, there are many false negatives and false positives in a generated density map. To address this issue, the authors propose a novel encoder-decoder convolution neural network (CNN) that fuses the feature maps in both encoding and decoding sub-networks to generate a more reasonable density map and estimate the number of people more accurately. Furthermore, the authors introduce a new evaluation method named the patch absolute error (PAE) which is appropriate to measure the accuracy of a density map. The extensive experiments on several existing public crowd counting datasets demonstrate that their approach achieves better performance than the current state-of-the-art methods. Finally, considering the cross-scene crowd counting in practice, the authors evaluate their model on some cross-scene datasets. The results show their method has good performance in cross-scene datasets.

EKF-Neural Network Observer Based Type-2 Fuzzy Control of Autonomous Vehicles

H. Taghavifar, C. Hu, Y. Qin, and C. Wei

This paper proposes a novel robust path-following strategy for autonomous road vehicles based on type-2 fuzzy PID neural network (PIDT2FNN) method coupled to an extended Kalman filter-based fuzzy neural network (EKFNN) observer. Uncertain Gaussian membership functions (MFs) are employed to self-adjust the universe of discourse for MFs using the adaptation mechanism derived from Lyapunov stability theory and Barbala's lemma. External disturbances are significant in autonomous vehicles by changing the driving condition. Furthermore, parametric uncertainties related to the physical limits of tires and the change of the vehicle mass may significantly affect the desired performance of autonomous vehicles. The robustness of the proposed controller against the parametric uncertainties and external disturbances is compared with one active disturbance rejection control (ADRC) algorithm and a linear-quadratic tracking (LQT) method. The obtained results in terms of the maximum error and root mean square error (RMSE) demonstrate the effectiveness of the proposed control algorithm to reach the minimized path-tracking error.

A Novel Hierarchical Flocking Control Framework for Connected and Automated Vehicles

F. Wang and Y. Chen

A novel hierarchical flocking control framework for multiple connected and automated vehicles (CAVs) is proposed to integrate path planning, speed profile generation, and nonlinear vehicle dynamics control. In the high-level layer, applying a 2-D flocking theory, the cooperative trajectories (paths and speeds) of multiple CAVs are produced via distributed control and shared information. In the low-level layer, the trajectory-tracking and vehicle orientation guidance of each vehicle are achieved by a feedforward and feedback control design. Demonstrated by the one-way three-lane highway simulation results, five CAVs controlled by the proposed flocking control framework can successfully complete a 2-D flocking coordination with velocity alignment, orientation control, and collision avoidance. The proposed flocking control framework for 2-D motions of CAVs can achieve safer and more efficient transportations than 1-D automated driving, such as platooning and cooperative adaptive cruise control.

Forecasting Transportation Network Speed Using Deep Capsule Networks With Nested LSTM Models

X. Ma, H. Zhong, Y. Li, J. Ma, Z. Cui, and Y. Wang

Accurate and reliable traffic forecasting for complicated transportation networks is of vital importance to modern transportation management. The complicated spatial dependencies of roadway links and the dynamic temporal patterns of traffic states make it particularly challenging. To address these challenges, the authors propose a new capsule network (CapsNet) to extract the spatial features of traffic networks and utilize a nested LSTM (NLSTM) structure to capture the hierarchical temporal dependencies in traffic sequence data. A framework for network-level traffic forecasting is also proposed by sequentially connecting CapsNet and NLSTM. An experiment on a Beijing transportation network with 278 links shows that the proposed framework with the capability of capturing complicated spatio-temporal traffic patterns outperforms multiple state-of-the-art traffic forecasting baseline models. The superiority and feasibility of CapsNet and NLSTM are also demonstrated, respectively, by visualizing and quantitatively evaluating the experimental results.

Interactive Visual Exploration of Human Mobility Correlation Based on Smart Card Data

X. Zhao, Y. Zhang, Y. Hu, S. Wang, Y. Li, S. Qian, and B. Yin

Public transportation agencies call for a visualization tool to detect patterns of crime (i.e., pickpockets and gangs) or

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missing commuters in public transportation systems. Few existing techniques have visually explored mobility correlations of targets and their companions characterized in diverse mobility types, by using discrete travel hints extracted from a massive amount of data. To fill this gap, a visual analytical system is provided to conduct a group-based and individual-based exploration of mobility correlations of passengers of interest, based on an auto integration of multiple queries. How passengers differ from or correlate with each other are further examined based on their spatio-temporal distributions in trajectories and ODs. Real-world case studies and user feedback demonstrate the effectiveness of the system in detecting specific targets and their companions featured in diverse mobility types, or in characterizing their spatiotemporal aggregation patterns for further tracking on public transportation systems.

Multi-Objective Timetabling Optimization for a Two-Way Metro Line Under Dynamic Passenger Demand

X. Wu, H. Dong, and C. K. Tse

In metro systems, the train passenger load is an important parameter that reflects both the utilization level of the trains provided by the operator and the comfort level of passengers in terms of crowdedness. In addition to minimizing the energy consumption and passengers' time cost, the train passenger load should also be optimized in order to maintain a high utilization rate of trains and an adequate level of comfort for passengers. In this paper, a multiobjective train scheduling optimization procedure is proposed to minimize the total energy consumption, the average waiting time, and the average maximum load deviation. Case studies on the Beijing Yizhuang line show that the proposed approach could effectively reduce the total energy consumption, the average waiting time, and the average maximum load deviation, thus ensuring high service quality and a low operational cost for the metro system.

SAPIENT: Enabling Real-Time Monitoring and Control in the Future Communication Infrastructure of Air Traffic Management

A. Virdis, G. Stea, and G. Dini

The SAPIENT system is a real-time monitoring and control infrastructure for air traffic management. Within the latter, aircrafts constantly measure the state and quality of their datalinks, and report these measurements to a ground entity, tagging them with a time/space reference. The ground entity, then, builds a map of the monitored portion of the sky and can feed back the information to the aircrafts themselves regarding conditions that they would not be able to measure otherwise. This allows optimal vertical handover decisions to be made, increasing service continuity and improving communication performance. The authors show that the SAPIENT system can be implemented using existing technologies, without the need for expensive hardware. Moreover, the authors show via simulation that a small, negligible increase in the communication overhead due to SAPIENT reporting brings about considerable benefits.

A Varying-Parameter Adaptive Multi-Layer Neural Dynamic Method for Designing Controllers and Application to Unmanned Aerial Vehicles

Z. Zhang, B. Zhou, L. Zheng, Z. Zhang, C. Song, and H. Pei

As an increasing number of unmanned aerial vehicles (UAVs) have been widely applied in many aspects, controllers with higher performance are preferred. In this paper, a new varying-parameter adaptive multi-layer neural dynamic based controller (termed as VP-AMND controller) design method is proposed and applied to controllers of multirotor UAVs. First, a varying-parameter convergent neural dynamic (VP-CND)-based controller is proposed and its convergence and robustness are theoretically proven. Second, by incorporating the adaptive control method into the VP-CND controller, the VP-AMND controller design method is proposed, of which the global stability, fast convergence speed, and strong robustness can be guaranteed. Different from traditional triple zeroing dynamic (TZD) and VP-CND controllers, the proposed VP-AMND controller with self-tuning rates can estimate the unknown disturbances and enhance the stability of the system in the face of uncertainty. Third, computer simulation results verify that the multirotor UAVs with VP-AMND controllers can track time-varying trajectories quickly and solve the parameter uncertainty and disturbances problems effectively.

Achieving Privacy-Preserving and Verifiable Data Sharing in Vehicular Fog With Blockchain

Q. Kong, L. Su, and M. Ma

Vehicular sensing is advocated to perform data collection by exploiting a plethora of vehicular onboard sensors; meanwhile, with the merging of vehicular sensing and fog computing, the deployed roadside units (RSUs) can act as fog nodes to collect and share vehicular sensory data at the network edge. However, there are still several problems in terms of the secure and reliable sharing of sensory data in vehicular fog. To resolve these issues, in this paper, the authors present an efficient, privacy-preserving and verifiable sensory data collection and sharing scheme with a permissioned blockchain in vehicular fog. During the data collection phase, by combining the homomorphic 2-DNF (where DNF stands for disjunctive normal form) cryptosystem and an identity-based signcryption scheme, their proposed scheme achieves the secure and verifiable computation of the average and variance of the collected vehicular sensory data. Meanwhile, to achieve efficient and reliable data sharing, they exploit a permissioned blockchain to generate and maintain an immutable and tamper-proof record of the derived sensory data. Through security analysis, the authors demonstrate security properties of the proposed scheme, in terms of location privacy preservation, verifiability, and immutability. Performance evaluations are also performed to validate the efficiency of the proposed scheme, i.e., improvements in computation and communication efficiency in comparison with a scheme without exploiting the blockchain technique.

Millimeter Wave MISO-OFDM Transmissions in an Intra-Wagon Environment

C. Sanchis Borrás, J.-M. Molina-García-Pardo, L. Rubio, J. Pascual-García, V. M. R. Peñarrocha, L. J. Llacer, and J. Reig

In this paper, the maximum achievable throughput is analyzed in the intra-wagon channel when multiple-input single-output (MISO) and orthogonal frequency division multiplexing (OFDM), MISO-OFDM, techniques are used. This analysis is performed from real wideband propagation channel measurements at 28 and 37 GHz, two potential frequency bands to deploy the future fifth-generation (5G) wireless communications networks. Four different scenarios in terms of the access point (AP) and user equipment (UE) positions inside the wagon have been considered, using four and eight antennas at the AP. The performance of both quasi-orthogonal space-time block code (QSTBC), combined with Hadamard matrices, and transmit beamforming techniques is studied and evaluated from simulation results. The simulation results take into account the signal-to-noise ratio (SNR) and the antenna correlation for each antenna array configuration at the AP. These results provide useful insight to better understand the intra-wagon channel properties and deploy the future 5G wireless networks in this particular scenario at mm-Wave frequencies, where high-data-rates are expected to support different types of digital applications.

A Spatial–Temporal Attention Approach for Traffic Prediction

X. Shi, H. Qi, Y. Shen, G. Wu, and B. Yin

An attention-based deep learning model is proposed for traffic foresting, which captures spatial, short-term temporal, and long-term periodical dependencies dynamically. The model incorporates a novel attention-based encoder-decoder architecture, where the spatial attention learns the weight of each node, and the temporal attention selects relevant encoder hidden states. The experimental results on real-world traffic datasets showed that the proposed approach achieved better results than state-of-the-art baselines.

Fuzzy Inference Enabled Deep Reinforcement Learning-Based Traffic Light Control for Intelligent Transportation System

N. Kumar, S. S. Rahman, and N. Dhakad

Existing fixed traffic light control systems split the traffic light signal into fixed duration and run in an inefficient way; therefore, it suffers from long waiting time, waste of fuel, and increase in carbon emission. Thus, a dynamic and intelligent traffic light control system (DITLCS) is proposed which runs in three modes, namely, fair mode, priority mode, and emergency mode where all the vehicles are considered with equal priority, vehicles of different categories are given different level of priority, and emergency vehicles are given at most priority respectively. A deep reinforcement learning model is also proposed to switch the traffic lights in different phases (red, green, and yellow), and fuzzy inference system selects one mode among three modes, i.e., FM, PM, and EM, according to the traffic information. DITLCS is tested via realistic simulation on Gwalior city map of India using an open-source simulator, i.e., Simulation of Urban MObility (SUMO).

Connected Automated Vehicle Platoon Control With Input Saturation and Variable Time Headway Strategy

J. Chen, H. Liang, J. Li, and Z. Lv

The rationality of the spacing strategy directly affects automated vehicle safety and road utilization. It is necessary to consider practical actuator constraints in vehicle platoon control systems to ensure security and driving comfort. In this paper, an important actuator constraint and a more effective spacing strategy are embedded into the connected automated vehicle platoon control. A new consensus-based control approach with the input saturation and variable time headway (VTH) spacing strategy is proposed. The homogeneous time-varying communication delays are included in the consensus algorithm. By employing the Lyapunov–Krasovskii theorem and the Lyapunov–Razumikhin theorem, the global asymptotic stability conditions of the system under fixed topology and switching topology are derived, respectively. Numerical simulation results demonstrate the effectiveness of the proposed approach and the necessity of introducing the input saturation and VTH spacing strategy.

Reliable Path Planning for Drone Delivery Using a Stochastic Time-Dependent Public Transportation Network

H. Huang, A. V. Savkin, and C. Huang

Drones have been regarded as a promising means for parcel delivery, and several drone-based delivery schemes have been proposed. However, the drone-only scheme is limited in delivery range due to the bottleneck of battery capacity, and the drone–truck collaboration scheme is still with high labor cost. This paper proposes a new scheme where a drone can travel with public transportation vehicles on the roof. This system has the merits of significantly enlarging the delivery range and reducing the labor cost. This paper mathematically formulates the reliable drone path planning problem (RDPP) in the stochastic time-dependent public transportation network accounting the battery capacity constraint and develops a label setting algorithm to construct the reliable path for the drone such that it can deliver a customer within a given deadline.

Efficient Ladder-Style DenseNets for Semantic Segmentation of Large Images

I. Krešo, J. Krapac, and S. Šegvić

This paper presents a semantic segmentation approach for accurate and efficient semantic segmentation of large images. It is based on DenseNet architecture and ladder-style upsampling. The design uses lateral skip connections to blend the semantics of deep features with the location accuracy of the early layers. It utilizes an asymmetric architecture with a thick encoder and a thin decoder, which assigns much more capacity to recognition than localization. In comparison with widely used dilated approaches, this design substantially decreases space and time computational complexity while achieving better generalization. The effectiveness of the architecture is demonstrated with extensive experiments on Cityscapes, CamVid, ROB 2018, and Pascal VOC 2012 datasets.

A Smart, Efficient, and Reliable Parking Surveillance System With Edge Artificial Intelligence on IoT Devices

R. Ke, Y. Zhuang, Z. Pu, and Y. Wang

Cloud computing has been a mainstream computing service for years. Recently, with the rapid development in urbanization, massive video surveillance data are produced at an unprecedented speed. A traditional solution to deal with big data would require a large amount of computing and storage resources. With the advances in the Internet of Things (IoT), artificial intelligence, and communication technologies, edge computing offers a new solution to the problem by processing all or part of the data locally at the edge of a surveillance system. In this study, the authors investigate the feasibility of using edge computing for smart parking surveillance tasks, specifically, parking occupancy detection using the real-time video feed. The system processing pipeline is carefully designed with the consideration of flexibility, online surveillance, data transmission, detection accuracy, and system reliability. It enables artificial intelligence at the edge by implementing an enhanced single shot multibox detector (SSD). A few more algorithms are developed either locally at the edge of the system or on the centralized data server targeting optimal system efficiency and accuracy. Thorough field tests were conducted in the Angle Lake parking garage for three months. The experimental results are promising that the final detection method achieves over 95% accuracy in real-world scenarios with high efficiency and reliability. The proposed smart parking surveillance system is a critical component of smart cities and can be a solid foundation for future applications in intelligent transportation systems.

Distributed Event-Triggered Model Predictive Control for Urban Traffic Lights

N. Wu, D. Li, Y. Xi, and B. de Schutter

Effective traffic signal control strategies are critical for traffic management in urban traffic networks. Most existing optimization-based urban traffic control approaches update the traffic signal at regular time instants, where the length of the fixed update time interval is determined based on a trade-off between the computational efficiency and the control performance. Since event-triggered control (ETC) allows for more flexible and more efficient control than conventional time-triggered control by triggering the control action by events, and since it can refrain from redundant optimization while retaining a satisfactory behavior, the authors use an ETC scheme for traffic light control. In addition, based on the geographically distributed feature of traffic networks, a distributed paradigm is adopted to reduce the computational complexity for the optimization. The authors propose a distributed threshold-based event-triggered control strategy, where the independent triggering of agents leads to an asynchronous update of traffic signals in the system. The triggered agent then solves a mixed-integer linear programming problem and updates its traffic signals. The proposed approach is evaluated under various traffic demands by simulation, and is shown to yield the best trade-off between control performance and computational complexity compared to other control strategies.

SALMNet: A Structure-Aware Lane Marking Detection Network

X. Xu, T. Yu, X. Hu, W. W. Y. Ng, and P.-A. Heng

Lane marking detection is a fundamental task, which serves as an important prerequisite for automatic driving or driver-assistance systems. However, the complex and uncontrollable driving road environment as well as the discontinuous lane marking appearance make this task challenging. In this work, a novel deep neural network architecture is presented to detect lane markings in a complex environment by analyzing their structure information. There are two contributions to the network design. First, a semantic-guided channel attention (SGCA) module is developed to select the low-level features of a deep convolutional neural network by taking the high-level features as guidance. Second, a pyramid deformable convolution (PDC) module is formulated to enlarge the receptive fields and to capture the complex structures of lane markings by applying deformable convolutions on multiple feature maps with different scales. Hence, their network can better reduce false detection and enhance lane marking structures simultaneously. The experimental results on three benchmark datasets for lane marking detection show that their method outperforms other methods on all the benchmark datasets.

Traffic Flow on a Ring With a Single Autonomous Vehicle: An Interconnected Stability Perspective

V. Giammarino, S. Baldi, P. Frasca, and M. L. Delle Monache

In recent years, field experiments have been performed on ring roadways with human-driven vehicles or with a mix of human-driven autonomous vehicles. While these experiments demonstrate the potential for controlling traffic flows by a small number of autonomous vehicles, the theoretical framework about such a possibility is to a large extent incomplete. Indeed, most work on mixed traffic focused on classical asymptotical stability notions, neglecting that human drivers are prone to the interconnected instability known in literature as string instability. This work aims to enhance the existing theories to meet the questions raised by the field experiments. It starts from the observation that the standard notion of string stability on a ring roadway is too demanding for a mixed traffic scenario: therefore, a new interconnected stability definition, named weak ring stability, is proposed. This new interconnected stability notion, in combination with classical stability, can explain some phenomena observed in field experiments. and highlight the possibilities and limitations of traffic control via sparse autonomous vehicle. Furthermore, it allows designing AV controllers with improved string stability specifications, at the price of reducing the sparsity of the autonomous vehicles.

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