Editorial Statement

Signal Processing and Control challenges for Smart Vehicles

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Smart phones have changed not only the mobile phone market but also our society during the past few years. Could the next potential intelligent device may be the vehicle? Judging by the visibility, in all media, of the numerous attempts to develop autonomous vehicles, this is certainly one of the logical outcomes. Smart vehicles would be equipped with an advanced operating system such that the vehicles could communicate with others, optimize the operation to reduce fuel consumption and emissions, enhance safety, or even become self-driving. These combined new features of vehicles require instrumentation and hardware developments, fast signal processing/fusion, decision making and online optimization. Meanwhile, the inevitable increasing system complexity would certainly challenges the control unit design.

The overarching intention of this special issue is to present works dealing mainly (but not exclusively) with up-to-date solutions of signal processing, control, and optimization for smart vehicles. Emphasis is on advanced and practical methodologies to deal with the existing challenges for connected vehicles, intelligent transportation, lightweight vehicles, and low-emission engines. There are numbers of submissions from different countries and we have selected 15 papers for this special issue. The accepted papers are classified into three categories: hybrid and electric vehicles (5 papers), autonomous vehicles (5 papers), and smart systems (5 papers). What now follows is, for each category the papers titles, followed by a short summary/discussion.

Hybrid and Electric Vehicles

1. Xiaosong Hu, Clara Marina Martinez, and Yalian Yang, “Charging, Power Management, and Battery Degradation Mitigation in Plug-In Hybrid Electric Vehicles: A Unified Cost-Optimal Approach”
2. Liang Li, Xiangyu Wang, and Jian Song, “Fuel Consumption Optimization for Smart Hybrid Electric Vehicle During a Car-Following Process”
3. Yugong Luo, Shan Li, Shuwei Zhang, Zhaobo Qin, and Keqiang Li, “Green Light Optimal Speed Advisory for Hybrid Electric Vehicles”
4. Junzhi Zhang, Yutong Li, Chen Lv, Jinfang Gou, and Ye Yuan, “Time-varying Delays Compensation Algorithm for Powertrain Active Damping of An Electrified Vehicle Equipped with An Axle Motor During Regenerative Braking”
5. Guoguang Zhang, Zitian Yu, and Junmin Wang, “Correction of Contaminated Yaw Rate Signal and Estimation of Sensor Bias for an Electric Vehicle under Normal Driving Conditions”

Xiaosong Hu et al. study the energy management problem of plug-in hybrid electric vehicles (PHEVs) which are integrated in smart grid environment constitutes in their paper “Charging, Power Management, and Battery Degradation Mitigation in Plug-In Hybrid Electric Vehicles: A Unified Cost-Optimal Approach”. The goal of this paper is to deal with the energy management challenge by investigating the interactions among three important control tasks such as charging, on-road power management, and battery degradation mitigation. The original contributions of this paper are three-fold: a novel control framework is constructed for the purpose of minimizing the comprehensive daily operational expense of a PHEV; a simple but effective assessment of the optimization outcome is proposed with respect to price changes of battery and energy carriers; the potential effect of vehicle-to-grid power flow on the PHEV economy is compared and analyzed.

Hybrid electric vehicles have the capacity to simultaneously save energy and reduce emission. On the other hand, smart vehicles have the function of offering great convenience and safety for drivers. The paper entitled “Fuel Consumption Optimization for Smart Hybrid Electric Vehicle During a Car-Following Process” combines hybrid and smart technologies to achieve excellent performances. In the paper, a smart hybrid electric vehicle is selected to investigate a car-following process for the purpose of reducing fuel consumption. The model predictive control and some search skills are adopted to deal with the multi-objective optimization problem. Simulations and comparisons illustrate the advantages of the proposed method.

A novel optimal speed advisory strategy is presented by Yugong Luo et al. in their paper “Green Light Optimal Speed Advisory for Hybrid Electric Vehicles”. The strategy used for continuous intersections can help to reduce fuel consumption and passing time. To achieve the objectives, a map model of the complex fuel consumption for HEVs is firstly constructed. A genetic-algorithm-based nonlinear optimization approach is employed to solve the formulated problem which considering continuous intersections and traffic conditions.

The main goal of the paper by Junzhi Zhang et al. entitled “Time-varying Delays Compensation Algorithm for Powertrain Active Damping of An Electrified Vehicle Equipped with An Axle Motor During Regenerative Braking” is to develop a control algorithm to deal with the negative impacts of flexibility of the electrified powertrain system and the network delay induced by network communication. A stochastic model covering a real in-car network topology and a flexible electrified powertrain is established. Since the network-induced delay is generally time-varying, a predictive scheme is adopted to compensate for the delay. Simulation results and hardware-in-loop (HIL) tests are both carried out to validate the effectiveness of the proposed compensation scheme.

Developments/research in the area of hybrid electric vehicles, are naturally followed by researches on electric vehicles per se. In the paper entitled “Correction of Contaminated Yaw Rate Signal and Estimation of Sensor Bias for an Electric Vehicle under Normal Driving Conditions”, the authors study the problem of correcting the contaminated yaw rate signal via estimating the corresponding sensor bias. Since the vehicle model varies with respect to the vehicle longitudinal velocity, a robust gain-scheduling observer which is scheduling to the velocity is proposed and the Luenberger-like observer gain design method is proposed.

Autonomous Vehicles

6. Shichun Yang, Yaoguang Cao, Zhaoxia Peng, Guoguang Wen, and Konghui Guo, “Distributed Formation Control of Nonholonomic Autonomous Vehicle via RBF Neural Network”
7. Yue Wei, Ge Guo, and Liyuan Wang, “Event-Triggered Platoon Control of Vehicles with Time-varying Delay and Probabilistic Faults”
8. Xiaohui Li, Zhenping Sun, Dongpu Cao, Daxue Liu, and Hangen He, “Development of a New Integrated Local Trajectory Planning and Tracking Control Framework for Autonomous Ground Vehicles”

9. Min Zhu, Huiyan Chen, and Guangming Xiong, “A Model Predictive Speed Tracking Control Approach For Autonomous Ground Vehicles”
10. David D.L. Mascareñas, Christopher J. Stull, and Charles R. Farrar, “Autonomous Execution of the Precision Immobilization Technique”

Shichun Yang et al. study the formation problem of nonholonomic autonomous vehicle in their paper “Distributed Formation Control of Nonholonomic Autonomous Vehicle via RBF Neural Network”. The principle is to propose a distributed control scheme such that a group of nonholonomic autonomous vehicles can follow a pre-defined specified reference trajectory. The trajectory formation problem is firstly converted into a state consensus problem through a variable transformation. Then the state consensus distributed controllers are selected as RBF neural network torque controllers.

In the paper entitled “Event-Triggered Platoon Control of Vehicles with Time-varying Delay and Probabilistic Faults”, the authors investigate event-triggered platoon control of vehicles which are subject to probabilistic sensor and actuator faults. A new fault platoon model which is incorporated with communication delay, event-triggered scheme, and probabilistic faults is established. The control scheme is an output feedback control. Both the numerical simulations and experiments are provided to show the effectiveness of the proposed approach.

The authors in the paper entitled “Development of a New Integrated Local Trajectory Planning and Tracking Control Framework for Autonomous Ground Vehicles” deal with the problem of local trajectory planning and tracking control framework for autonomous vehicles. The obstacles avoidance along the reference path is considered and the smooth path is produced via a model-based predictive path generation algorithm. Moreover, a velocity control law is proposed. Both the safety and comfort performances are considered for the path optimization. Once the path is optimized, a combined feedforward and feedback controller is adopted for the path tracking. Real vehicle testing is performed to show the effectiveness of the proposed path optimization and tracking framework.

The main objective of the paper entitled “A Model Predictive Speed Tracking Control Approach For Autonomous Ground Vehicles” is to develop an efficient and fast speed tracking controller for autonomous ground vehicles. A switching algorithm determine whether the autonomous vehicle is in the driving or braking mode. It is well known that the computational load is a challenging for model predictive control.

Therefore, a simplified quadratic program algorithm is employed to reduce the computational time for the model predictive controller. Finally, the designed controller has been implemented in a 16-bit microcontroller.

In the work entitled “Autonomous Execution of the Precision Immobilization Technique”, the authors aim to develop a simple control policy based on velocity pursuit for the purpose of autonomously executing the precision-immobilization-technique (PIT) maneuver. The objective is achieved by only using a vision and range measurements which are both easily available for driverless autonomous cars. The effectiveness and the ability of the proposed control policy are demonstrated both in the simulation environment and the experiment tests. The work can help to improve the cyber-physical security for autonomous vehicles.

Smart Systems

11. Xing Xu, Wei Wang, Nannan Zou, Long Chen, and Xiaoli Cui , “A Comparative Study of Sensor Fault Diagnosis Methods Based on Observer for ECAS System”
12. Hao Zhang, “Empirical Analysis and Modeling of Manual Turnpike Tollbooths in China”
13. Lei Liu, Zhijun Li, Shiyu Liu, and Boxi Shen, “Effect of Exhaust Gases of Exhaust Gas Recirculation (EGR) coupling Lean-burn Gasoline Engine on NO_x Purification of Lean NO_x Trap (LNT)”
14. Dawei Qu, Jun Li, and Yu Liu, “The Particulate Filter Simulation and Regeneration Control Strategy Research”
15. Giulio Reina, Matilde Paiano, and Jose-Luis Blanco-Claraco, “Vehicle Parameter Estimation Using a Model-based Estimator”

Xing Xu et al. study the sensor fault diagnosis problem of electronically-controlled air suspension (ECAS) systems in their paper “A Comparative Study of Sensor Fault Diagnosis Methods Based on Observer for ECAS System”. The study is based on a non-linearized 3-DOF 1/4 vehicle model and the used methods including an extended Kalman filter (EKF), a strong tracking filter (STF), and the cubature Kalman filter (CKF) with numerical precision. Comparison results show that three approaches achieve similar performance in the sensor fault diagnosis process.

The author in the paper “Empirical Analysis and Modeling of Manual Turnpike

Tollbooths in China” targets to deal with the problem of low-level service satisfaction at tollbooths of many turnpikes in China. Based on the collected data from six tollbooths of a typical turnpike in China, the author not only analyzes vehicle's time-dependent arrival process, but also analyzes the collector's time-dependent service time. It infers from the analytical results that: 1. the vehicle arrival process satisfies a non-homogeneous Poisson process; 2. the collector service time is a log-normal distribution.

In order to satisfy the vehicle emission regulations, the smart after-treatment system is necessary for modern vehicle. In this special issue, we have selected two papers focusing on the engine emissions. These two papers entitled “Effect of Exhaust Gases of Exhaust Gas Recirculation (EGR) coupling Lean-burn Gasoline Engine on NO_x Purification of Lean NO_x Trap (LNT)” and “The Particulate Filter Simulation and Regeneration Control Strategy Research” can help the readers to understand the after-treatment systems including EGR, LNT and Diesel-engine particulate filter (DPF).

Similar to the control problem, the estimator design is also a typical problem for vehicle systems. In the paper entitled “Vehicle Parameter Estimation Using a Model-based Estimator”, the authors propose estimator design approach for motion states and parameters of the vehicle which are not available. As the estimator design is model based, basic lateral dynamics of a vehicle is discussed and the Extended Kalman filter is adopted.

It is almost natural to consider MSSP as an outlet for many of the disciplines and tools involved in the areas addressed by this Special Issue. Many of these would seem to parallel the interest and focus area of many of our readers and contributors. We now certainly look forward to seeing future worthwhile contribution submitted to us.

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