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Editorial

Advanced Control and Optimization with Applications to Complex Automotive Systems

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With increasing and tightening requirements on the control and optimization performance, the traditional control and optimization strategies may not qualify in many application problems. To meet the challenges and requirements, advanced control and optimization methodologies should be employed or developed. Here, the advanced control and optimization denote the ones which, in principle, can best achieve the objectives in the presence of nonlinearities, highly interactivities, or newly emerged operating circumstances. As the advanced control and optimization will provide a basis for the design and operation of practical systems, these advanced techniques would result in substantial and sustainable benefits.

The overall aims of this special issue are twofold: (1) to provide an up-to-date overview of the research directions in the advanced control and optimization; (2) to illustrate how to formulate problems from automotive systems and develop suitable theory to solve the corresponding problems. Of particular interest the papers in this special issue are devoted to the development of advanced control and optimization including network control, nonlinear model predictive control, dynamic programming, and integral programming, with applications to complex automotive systems including vehicle dynamics and control, combustion and emission control, and vehicle integration and optimization, for instance. Topics in this special issue include, but are not limited to: (1) network analysis and protocol optimization, (2) fast nonlinear model predictive control and optimization, (3) advanced vehicle dynamics and control, (4) intelligent systems and mobility, (5) advanced vehicle integration and optimization, (6) robust and optimal control, and (7) information constraints and faults.

We have solicited considerable submissions to this special issue worldwide from control engineers and researchers, automotive engineers and researchers, electric engineers and researchers, and mathematics scientists. After a stringent peer review process, 37 submissions have been accepted, which covers electrified vehicles, vehicle dynamics and powertrain control, road information and vibration attenuation, control and optimization theory and applications, and networks and autonomous vehicles.

The electrification has been the consistent topic almost since the birth of the traditional engine-powered vehicles. In particular, recently, the electrification process has been enhanced due to the requirements on the fuel economy and emissions. In the work entitled "*Experimental study on communication delay of powertrain system of plug-in hybrid electric vehicles*" by D. Wang et al., a mathematical model of the vehicle system with delay is established. An experimental platform is developed to test the communication delays and identify the established mathematical model. In another work entitled "*A study on control strategy of regenerative braking in the hydraulic vehicle based on ECE regulations*" by T. Liu et al., the regenerative braking strategy is investigated for hydraulic hybrid vehicles. The simulation results validate the effectiveness and the application perspective of the proposed strategy. C. B. Regaya et al. develop a scheme of simultaneous estimation of rotor resistance and the rotor speed of an induction motor in the paper "*Electric drive control with rotor resistance and rotor speed observers based on fuzzy logic.*" Two adaptive observers using fuzzy logic are designed and the optimal control gain is determined by a simple algorithm. A control strategy named least square support vector machines inverse control is proposed for a three-phase induction motor for electric vehicle in "*A high-performance control method of constant V/f-controlled induction motor drives for electric vehicles*" by L. Chen et al. A modified particle swarm optimization is used to determine the optimal parameters. In the work entitled "*Resident plug-in electric vehicle charging modeling and scheduling mechanism in the smart grid*" by P. Han et al., a distribution grid profile model with plug-in electric vehicle charging power is developed to study the resident charging effects on the distribution grid. The real data is used to identify the model and a queuing-theory-based scheduling mechanism is explored. The energy management problem for plug-in series-parallel hybrid electric bus is addressed in "*Global optimal energy management strategy research for a plug-in series-parallel hybrid electric bus by using dynamic programming*" by H. He et al. Employing the dynamic programming for the optimization, the fuel economy is improved by 53.7% compared with the corresponding conventional bus.

As the vehicle may be driven at a high speed especially on an highway, the vehicle dynamics and control such as the lateral and longitudinal dynamics is extremely important. In the paper entitled "*Optimal slip ratio based fuzzy control of acceleration slip regulation for four-wheel independent driving electric vehicles*" by G. Yin et al., an acceleration slip regulation algorithm is proposed for four-wheel independent driving electric vehicles. The utilized control method is the fuzzy logic control. It infers from the comparison that the vehicle driving stability and safety are both improved. R. Wang et al. study the motion control of four-wheel independently driven electric vehicles in "*Motion control of four-wheel independently actuated electric ground vehicles considering tire force saturations.*" The hierarchy controller consists of a high-level one and a low-level one. The high-level controller is used to generate the virtual control efforts to track the desired vehicle model. And the low-level one is to do the control allocation. R. He et al. analyze the braking performance for eddy current and electrohydraulic hybrid brake system in the work named "*Brake performance analysis of ABS for eddy current and electrohydraulic hybrid brake system.*" The intelligent control is employed to the integrated vehicle dynamics in the work "*Nonlinear analysis and intelligent control of integrated vehicle dynamics*" by C. Huang et al. The nonlinearity is also analyzed. For the clutch shifting investigation, there are four papers from two research groups: "*Research on shifting control method of positive independent mechanical split path transmission for the starting gear*" by J. Xi et al., "*Research on conflict decision between shift schedule and multienergy management for PHEV with automatic mechanical transmission under special driving cycles*" by J. Xi and Y. Chen, "*Fuzzy determination of target shifting time and torque control of shifting phase for dry dual clutch transmission*" by Z. Zhao et al., and "*Sliding mode variable structure control and real-time optimization of dry dual clutch transmission during the vehicle's launch*" by Z. Zhao et al. Though the main topic is similar, these four papers have different investigation points and different contributions inside.

The demands on the vehicle ride comfort are receiving more and more attention. The future direction is to improve and modify the passive suspension systems. Active suspension and semiactive suspension are two alternative options. The active suspension system is designed in "*Static output-feedback control for vehicle suspensions: a single-step linear matrix inequality approach*" by J. Rubio-Massegu et al. The employed control law is the static output-feedback control. It is well known that the optimal feedback gain of the static output feedback control is difficult to be determined. The authors propose a novel noniterative algorithm to derive the feedback gain. The finite-frequency control is used in "*Finite frequency vibration control for polytopic active suspensions via dynamic output feedback*" by Y. Zhang et al. for the active suspension design. Compared with the traditional entire-frequency optimization, the solution is improved a lot. The ride height adjusting controller design problem is investigated in "*Dynamic ride height adjusting controller of ECAS vehicle with random road disturbances*" by X. Xu et al. The variable structure control technique can be seen in this paper. In the paper entitled "*Considering variable road geometry in adaptive vehicle speed control*" by X. Yan et al., the road geometry is involved in the vehicle speed control. The adaptive vehicle speed controller is designed by using the Hamilton-Jacobi Inequality. In the work named "*Adaptive real-time estimation on road disturbances properties considering load variation via vehicle vertical dynamics*" by W. Yu et al., a Kalman filter is employed to estimate the road disturbance. Moreover, the recursive least-squares estimation is employed to estimate the sprung mass. The key contribution is to categorize the road condition into six special ranges which can be applied to the suspension control. J. Cao et al. investigate the driver model in the paper "*A driver modeling based on the preview-follower theory and the jerky dynamics.*" Simulation results carried out via CarSim show the advantages and the effectiveness of the proposed model. In the work entitled "*A frequency compensation algorithm of four-wheel coherence random road*" by J. Feng et al., the authors aim to deal with the different road power spectral densities between left and right wheels. A frequency compensation algorithm is proposed to compensate for the difference. Q. Yang et al. design the vehicle suspension with an adaptive optimization approach in the work "*An adaptive metamodel-based optimization approach for vehicle suspension system design.*"

The control and optimization theory has obtained a lot of witness during the past decade owing to the requirements of the emerging applications. In the work entitled "*Collision-free and energy-saving trajectory planning for large-scale redundant manipulator using improved PSO*" by M. Jin and D. Wu, the particle swarm optimization (PSO) algorithm is modified to overcome the drawbacks of the original algorithm. In the work entitled "*Actuator saturation constrained fuzzy control for discrete stochastic fuzzy systems with multiplicative noises*" by W.-J. Chang et al, the discrete-time fuzzy systems with multiplicative noises are investigated. Sufficient conditions are derived to guarantee the stability of the closed-loop nonlinear stochastic systems subject to actuator saturation. J. Asprion et al. summarize the optimization problem in Diesel engines in the work "*Optimal control of diesel engines: numerical methods, applications, and experimental validation.*" In the work entitled "*Optimization problem for physical design automation*", the physical design automation is optimized in the directions of area and interconnect length. A hybrid evolutionary algorithm is applied on the problem. B. Wang et al. develop a novel controller for integrated electric parking brake system in the paper "*Slide mode control for integrated electric parking brake system.*" The sliding mode controller is applied to control the clamping force such that vehicle is parked firmly. The stability and the H_∞ performance of switched systems with time-varying delays are investigated by C. Qin et al. in the paper "*Robust stability and H_∞ stabilization of switched systems with time-varying delays using delta operator approach.*" Numerical examples show the effectiveness of the proposed design method. In the paper entitled "*Quality-related process monitoring based on total kernel PLS model and its industrial application*" by K. Peng et al., the adaptively of projection to latent structure is enhanced. In addition, the proposed method is applicable for nonlinear systems. In the paper entitled "*Peak power demand and energy consumption reduction strategies for trains under moving block signalling system*" by Q. Gu et al., two novel approaches named service headway braking and extending stopping distance interval are developed, in which the restarting times of the trains are staggered and the traction periods are reduced.

The network control and autonomous vehicles are two promising topics which are not isolated from each other. In the work entitled "*Spatial path following for AUVs using adaptive neural network controllers*" by J. Zhou et al., the path following for autonomous vehicles is studied. Both ocean current and the systemic variations are considered. Observers are designed to observe the ocean current which is treated as the external disturbance. The uncertain parameters are also estimated. The bilateral control is studied in "*Stability problem of wave variable based bilateral control: influence of the force source design*" by D. Tian et al. The influence of the time delay is considered. Experimental test results validate the developed theory. X. Gu et al. study the trajectory planning of multiple unmanned combat aerial vehicles in the paper "*A virtual motion camouflage approach for cooperative trajectory planning of multiple UCAVs.*" Simulation experiments are provided to show the performance of the proposed approach. A path planning method for unmanned air vehicles is developed in the paper "*Efficient UAV path planning with multiconstraints in a 3D large battlefield environment*" by W. Zhan et al. The proposed method has the capacity to find the optimal trajectory between two points. Experimental test results are also offered. For the CAN-network-induced delay, D. Wang et al. proposed the delay model of average online delay in the work entitled "*Modeling and analysis of online delay of nonperiodic CAN message.*" The actual delays among several CAN nodes are measured to validate the developed model. As the CAN bus has been widely used in industry, the developed model can be employed to improve the control performance. The game theoretic approach is used to deal with the distributed localization problem in "*On distributed localization for road sensor networks: a game theoretic approach*" by J. Jia et al. Several techniques are also provided to enhance the convergence speed of the algorithm. In the work entitled "*Optimal ascent guidance for air-breathing launch vehicle based on optimal trajectory correction*" by X. Lu et al., based on the optimal trajectory correction, an optimal guidance algorithm is proposed for air-breathing launch vehicle which is a nonlinear system.

Acknowledgments

This special issue provides an up-to-date research progress in the area of advanced control and optimization with applications to complex vehicle systems such as the ground vehicle and underwater vehicles. We really appreciate all the authors for contributing submissions to the special issue. Meanwhile, we also would like to acknowledge all the anonymous reviewers for the voluntary work. In addition, special thanks are due to the China Postdoctoral Science Foundation (2012M520028), the National Natural Science Foundation of China (51205155, 61374213), and the National Basic Research Program of China (973 Program) (2011CB711201) for supporting authors' research.

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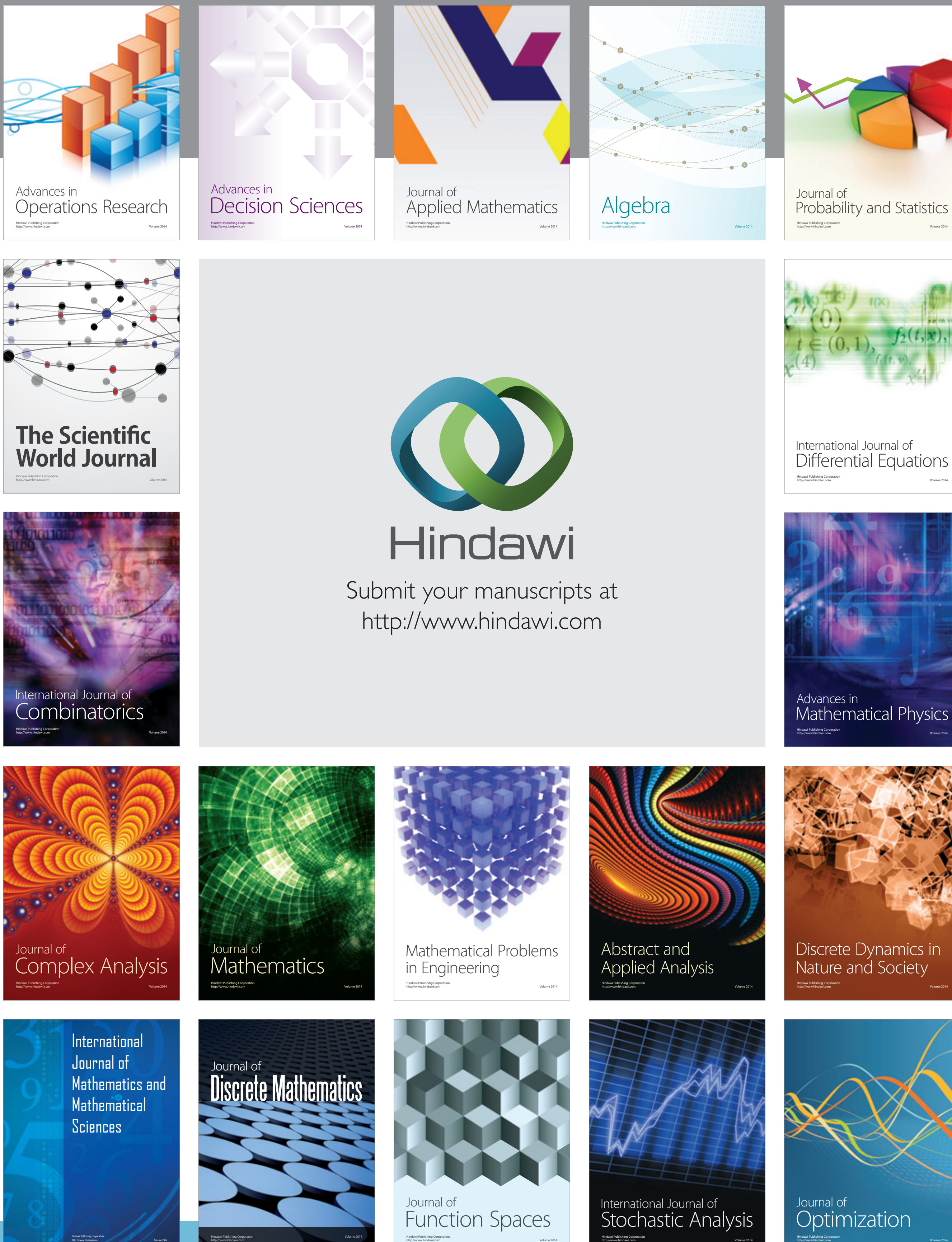
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