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Editorial

Special issue on control theory and applications in honor of the 60th birthday of Professor Frank L. Lewis

It is our great pleasure to put up this special issue in Journal of Control Theory and Applications in honor of the 60th birthday of Professor Frank Lewis, who has made many significant contributions to the field of control engineering through the years, and who is regarded as a pioneer in many areas in control and automation, which includes applied optimal control and geometric systems theory in his earlier research period, and his recent focus on intelligent nonlinear control, neural network feedback control, optimal control for nonlinear systems, H-infinity (game theory) control, approximate dynamic programming, discrete event supervisory control, intelligent diagnostics and prognostics, to name a few. Featured in this special issue are 16 manuscripts on control theory and applications, of which many are from the personal and academic friends of Professor Frank Lewis, and were presented at the Third Annual Workshop organized by the Robotics and Automation/Control Systems Joint Chapter of IEEE Hong Kong Section, held in Macau, China, May 31-June 1, 2009, in celebrating Frank's birthday.

Dr. Lewis obtained his Bachelor degree in Physics and Electrical Engineering and Master degree in Electrical Engineering at Rice University in 1971. He then spent six years in the U.S. Navy, serving as Navigator and Executive Officer and Acting Commanding Officer. In 1977, he received the Master of Science in Aeronautical Engineering from the University of West Florida. In 1981, he obtained his Ph.D. degree at Georgia Institute of Technology, where he was employed as a professor from 1981 to 1990. He is currently a professor of Electrical Engineering at the University of Texas at Arlington (UTA), where he was awarded the Moncrief-O'Donnell Endowed Chair in 1990 at the Automation & Robotics Research Institute (ARRI). Dr. Lewis is the author of 6 U.S. patents, over 200 journal papers and 14 books. He served/serves on many editorial boards. He received Fulbright Research Award 1988, American Society of Engineering Education F.E. Terman Award 1989, International Neural Network Society Gabor Award 2009, U.K. Institute of Measurement and Control Honeywell Field Engineering Medal 2009, 3 Sigma Xi Research Awards, UTA Halliburton Engineering Research Award, UTA Distinguished Research Award, ARRI Patent Awards, and various best paper awards. He was listed in Ft. Worth Business Press Top 200 Leaders in Manufacturing, and was appointed to NAE Committee on Space Station in 1995 and IEEE Control Systems Society Board of Governors in 1996. In 1998, Dr. Lewis as elected an IEEE Control Systems Society Distinguished Lecturer. He is Fellow of the IEEE, Fellow of IFAC, Fellow of the U.K. Institute of Measurement & Control.

We summarize in the following the key contributions of each manuscript included in this special issue.

. Global robust stabilization of feedforward systems with uncertainties by T. Chen and J. Huang

The paper studies the global robust stabilization problem for a class of feedforward systems that is subject to both dynamic and time-varying static uncertainties. A small gain based bottom-up recursive design is developed for constructing a nested saturation control law. At each recursion, two versions of small gain theorem with restrictions are employed to establish the global attractiveness and local stability of the closed-loop system at the equilibrium point, separately.

. A MATLAB toolkit for composite nonlinear feedback control – improving transient response in tracking control by G. Cheng, B. M. Chen, K. Peng and T. H. Lee

It presents a MATLAB toolkit with a user-friendly graphical interface for composite nonlinear feedback control system design. The toolkit can be utilized to design a fast and smooth tracking controller for a class of linear systems and nonlinear systems with actuator nonlinearities as well as with external disturbances. The parameters of the controller can be tuned easily on the user panel or autotuned by the toolkit. The usage and design procedure of the toolkit are illustrated by practical examples.

. Three-dimensional fuzzy logic system for process modeling and control by H. Li, X. Duan and Z. Liu

The traditional fuzzy logic system (FLS) can only model and control the process in two-dimensional nature. Many of

real-world systems are of multidimensional features, such as, thermal and fluid processes with spatiotemporal dynamics, biological systems or decision-making processes that contain stochastic and imprecise uncertainties. These types of systems are difficult for the traditional FLS to model and control because they require the third dimension for spatial or probabilistic information. The type-2 fuzzy set provides the possibility to develop a three-dimensional fuzzy logic system for modeling and control of these processes in three-dimensional nature.

. Nonsynchronized state estimation of uncertain discrete-time piecewise affine systems by J. Qiu, G. Feng and H. Gao

This paper investigates the problem of robust H_∞ state estimation for a class of uncertain discrete-time piecewise affine systems where state space instead of measurable output space partitions is assumed so that the filter implementation may not be synchronized with plant state trajectory transitions. Based on a piecewise quadratic Lyapunov function combined with S-procedure and some matrix inequality convexifying techniques, two different approaches are developed to the robust filtering design for the underlying piecewise affine systems. It is shown that the filter gains can be obtained by solving a set of linear matrix inequalities.

. Further decomposition for singular systems and its properties on geometric subspace by J. Yang and M. Li

The main contribution of this work is on the establishment of the relationship between the geometric subspaces and the structural decomposition of continuous-time singular systems. A further decomposition is investigated to clearly reveal the supremal output-nulling (ON)-$(A, E, \mathrm{Im}B)$-invariant subspace of singular systems. It is shown that the supremal ON-$(A, E, \mathrm{Im}B)$-invariant subspace can be obtained in an explicit fashion.

. Feedback linearization of the nonlinear model of a small-scale helicopter by B. Song, Y. Liu and C. Fan

This paper investigates the dynamic characteristics of a model helicopter and proposes an integrated nonlinear model of a small-scale helicopter for hovering control. It is proved that the nonlinear system of the small-scale helicopter can be transformed to a linear system using the dynamic feedback linearization technique. Simulation results validate the feasibility of the nonlinear controller.

. On iterative learning control design for tracking iteration-varying trajectories with high-order internal model by C. Yin, J. Xu and Z. Hou

Based on high-order internal models (HOIM), this paper develops a new iterative learning control (ILC) scheme for a class of iteration-varying reference trajectory tracking problem. Profiting from using classical Z-transformation in the discrete iteration domain, the nonrepetitiveness phenomenon is quantified in a simple and straightforward form for the first time by using a polynomial structure. The boundedness property and associated conditions of HOIM-based ILC are also analyzed and presented.

. A gain-varying UIO approach with adaptive threshold for FDI of nonlinear F16 systems by J. Xu, K. Y. Lum and A. P. Loh

It presents a discrete gain-varying unknown input observer (UIO) method for actuator fault detection and isolation (FDI) problems. A novel residual scheme together with a moving horizon threshold is proposed. This design methodology is then applied to a nonlinear F16 system with polynomial coefficient expressions. The simulation results illustrate that a satisfactory FDI performance can be achieved even when the F16 system is under the environment of model uncertainties, exogenous noise and measurement errors.

. Dynamic modeling and control of extracellular ATP concentration on vascular endothelial cells via shear stress modulation by C. Xiang, L. Cao, K. Qin and T. H. Lee

A new dynamic model for cell-deformation-induced adenosine triphosphate (ATP) release from vascular endothelial cells (VECs) is proposed in this paper to quantify the relationship between the ATP concentration at the surface of VECs and blood flow-induced shear stress. The simulation results demonstrate that the proposed new dynamic model is more consistent with the experimental observations than the existing models in the literature. Furthermore, it is the first time that a PID feedback controller is applied to modulate extracellular ATP concentration.

. Design of switched linear systems in the presence of actuator saturation and $\mathcal{L}$-infinity disturbances by L. Lu, Z. Lin and H. Fang

The problem disturbance tolerance/rejection of a switched system resulting from a family of linear systems subject to actuator saturation and $\mathcal{L}_\infty$ disturbances is studied in this paper. The design of feedback gains and switching scheme are

formulated and solved as constrained optimization problems. When all systems in the family are identical, the switched system reduces to a single system under a switching feedback law. Simulation shows that such a switching feedback law could possess stronger disturbance tolerance/rejection capability than a single linear feedback law can.

. Stabilization and H-infinity control for interval descriptor systems by S.-W. Kau, W.-R. Horng and C.-H. Fang

This paper considers H_∞ control problem for interval descriptor systems. Necessary and sufficient LMI-based conditions are derived for quadratic-like H_∞ control analysis of interval descriptor systems. Using the analysis result, two types of feedback controllers are designed so that the closed-loop interval descriptor systems are admissible with H_∞-norm less than a prescribed value.

. Limitations in tracking systems by I. L. Hurtado, C. T. Abdallah and S. K. Jayaweera

In this paper information theoretical conditions for tracking systems are obtained. The mutual information rate between the feedback signal and the reference input signal are used to quantify the information about the reference signal that is available for feedback. The mutual information is shown to be upper bounded by the unstable eigenvalues of the plant and the channel capacity. When the channel capacity reaches a lower limit, the feedback signal becomes completely uncorrelated with the reference signal.

. Observer-based H-infinity control in multiple channel networked control systems with random packet dropouts by W. Che, J. Wang and G. Yang

The work investigates the observer-based H_∞ control problem for networked control systems with random packet dropouts. A general packet dropout model with multiple independent stochastic variables in the case of multiple channels is adopted. With the consideration of the sensor-to-controller and controller-to-actuator packet dropouts at the same time, a new method is proposed based on a separation lemma to design an observer-based H_∞ controller, so that the closed-loop system is mean-square exponentially stable and also achieves a prescribed H_∞ performance level.

. Infinite horizon LQR for systems with multiple delays in a single input channel by S. Liu, L. Xie and H. Zhang

It is concerned with the linear quadratic regulation problem for both linear discrete-time systems and linear continuous-time systems with multiple delays in a single input channel. The solution is given in terms of the solution of a two-dimensional Riccati difference equation for the discrete-time case and a Riccati partial differential equation for the continuous-time case. The conditions for convergence and stability are provided.

. The structure of canalizing functions by Z. Li and D. Cheng

This paper discusses the structure of the canalizing function, which is a logical function. Using a new matrix product, namely semitensor product, the logical function is expressed in its matrix form. From its matrix expression, a criterion is obtained to test whether a logical function is a canalizing function. Then a formula is obtained to calculate the number of canalizing functions. Moreover, an algorithm is presented to generate canalizing functions. Finally, some results are extended to seminested canalizing functions.

. Practical disturbance rejection of a class of nonlinear systems via sampled output by B. Wu and Z. Ding

It presents a sampled-data control scheme for disturbance rejection of nonlinear systems in output feedback form. Obtained based on the emulation approach, the proposed sampled-data control uses the sampled output and a discrete-time implementation of the filter and the internal model. The proposed control is shown to render the overall system stable. In particular, the disturbance is practically rejected in the sense that the ultimate bound of the output can be arbitrarily small by choosing appropriate gain parameters.

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