Special Issue on “Recent Advances in Robust Adaptive Control”

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As compared to conventional adaptive control, robust adaptive control aims to provide robustness against unmodeled dynamics, coupling effects, and other endogenous and exogenous disturbances. Robust adaptive control has been an active research area over more than three decades, and has flourished in many application domains. Despite the advances, some bottlenecks still need to be circumvented for further progressing in the field. This special issue collects recent advances in robust adaptive control from theoretical and application perspectives.

Theoretical aspects in robust adaptive control addressed in this special issue are:

- Relaxing the persistence of excitation (PE) condition, standard in adaptive control and estimation: Katuyar, Roy, and Bhasin propose a novel condition, called finite persistence excitation (f-PE), milder than PE in terms of excitation requirement and online verifiability.
- State-dependent uncertainties without a priori bounds: Shukla, Roy, and Gupta consider an adaptive control problem in which the uncertainties cannot be bounded a priori by any constant, but should be tackled in their state-dependent nature.
- Robust adaptive control for multiple-input multiple-output (MIMO) nonlinear systems: Psillakis and Oikonomidis utilize a nonlinear proportional-integral (PI) controller that can handle both unknown nonlinearities and unknown control directions.
- Super-twisting with variable gains: Rodrigues and Oliveira propose a generalization of recently introduced super-twisting algorithms to a multivariable setup with arbitrary relative degrees, output-feedback, and variable gains.
- Evolutionary games with uncertainties: Liang, Cui, Zhou, and Ding use adaptive control to extend the well-known two-strategy evolutionary games to the stochastic case, and derive bounds on the strength of noise/time delay guaranteeing stability.
- Singular perturbation in the presence of uncertainties: Rayguru, Mohan, Ramalingam, and Elara use adaptive control techniques to enforce time scale separation and facilitate dynamic inversion in singular perturbation-based loops with saturating actuators.

Robust estimation can be considered a dual problem of robust adaptive control, and contributions in this special issue include the following:

- Extended Kalman Filter (EKF): Che, Zheng, and Yuan propose a recursive least square multiplicative (EKF) that can tackle unmodeled and time-varying dynamic and kinematic effects typically arising in unfirm capture scenarios.
- Neural-network-enhanced Kalman filter (NNEKF): Sun, Zheng, and Li utilize virtual observations, obtained from a neural network using uses past observations, to improve the precision and robustness of the standard Kalman filter.
- Resilient state estimation in sensor networks, solved by Qian, Guo, Zhao, Xu, and Fei in the presence of randomly occurring communication delays and missing measurements. A novel sensor model is introduced to describe these impairments in a unified way.
- Recursive least squares (RLS) for control, which is tackled by Baldi, Zhang, and Liu in the framework of Recursive Least Squares-Temporal Difference (RLS-TD), using an instrumental variable perspective.

Apart from several applications investigated in the aforementioned works (steer-by-wire control, visual servoing, estimation of space debris, etc.) the special issue also cover additional applications requiring robust adaptive control tools, such as:

- Cable-drogue docking for autonomous underwater vehicles, solved by Li, Liu, Li, Guo, and Zhang via a proportional-integral-differential (PID) in which the control parameters are adaptively optimized by a Q-learning neural network.
- Adaptive cooperative driving for automated vehicles, which is framed by Yang, Liu, and Yu is a distributed model reference adaptive control problem, and where robustness is increased by reducing the number of variables communicated from preceding vehicles.
- Regenerative braking in electric vehicles, addressed by Mei, Karimi, Yang, Xu, and Huang via a fuzzy sliding-mode control scheme under an adaptive control strategy. The fuzzy logic controller adjusts the sliding mode parameters according to the slip ratio.

We hope you will enjoy the special issue and find it inspiring for your research and development activities in the field of robust adaptive control!

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