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SPECIAL ISSUE ON ‘‘THEORETICAL AND PRACTICAL CHALLENGES IN LEARNING CONTROL’’

Learning control, including iterative learning control (ILC) and repetitive learning control (RLC), has been widely used in industrial applications such as chemical reactors, batch processes, robotic manipulators, high precision CNC machining, hard disc drives, milling and laser cutting, traffic flow control systems, and rehabilitation robotic systems. Although learning control algorithms have been successfully applied to various engineering processes and devices, there are still many challenges including the fundamental understanding of robust design in the presence of model uncertainty, disturbance and noise, novel applications and the development of new analysis tools.

This special issue invites original articles that address both theoretical and application-oriented challenges in learning control, including novel applications, performance improvement along iteration domain and time domain, new analysis tools, and any related technologies in learning control. Moreover, this special issue also aims at encouraging readers to participate in this promising and challenging research area.

The papers included in the issue can be divided into four groups. The first group of papers investigated various aspects of adaptive ILC algorithms from robustness, relaxing standing assumptions, as well as how to achieve the desired performance. The first paper by Altin and Barton discussed the robustness of adaptive ILC using the well-known Rohrs' Example. The second paper in this group by Chi, Lin, Huang, Chien and Feng proposed a new adaptive terminal iterative learning control algorithm for non-repetitive terminal point tracking. The third paper in this group by Z. Liu and J. K. Liu discussed the application of adaptive ILC to a flexible manipulator, which can be modelled by a partial differential equation. A new adaptive ILC algorithm was proposed to ensure that the prescribed performance was satisfied.

The second group focused on the performance analysis and improvement of learning control. The paper by Li and Huang proposed new ILC algorithms that can reduce the gain of the controller and improve the tracking performance for a large class of heat transfer systems. The paper by Teo, Eielsen, and Fleming presented a design procedure to generate more robust filters for RLC algorithms, with experimental verification on a nanopositioning system. Boeren, Blanken, Bruijnen, and Oomen proposed new ILC algorithms that can provide optimal estimation of rational feedforward controllers with a high degree of performance. The effectiveness of the proposed ILC algorithms has been demonstrated in their application to a wafer stage. The paper by Yovchev, Delchev and Krastev proposed an efficient computational procedure for path planning with respect to robotic manipulators with state space constraints, employing the design of ILC algorithms. Without using inverse kinematics, Tatlicioglu, Dogan, Zergeroglu, and Cetin developed new RLC algorithms that can “learn” uncertainties in the robot manipulator dynamics, leading to the desired tracking performance as demonstrated in experimental results on a robot manipulator developed in-house.

The third group of papers presented applications of learning control in multi-agent systems and networked control systems, where the quality of communication plays an important role in the closed loop performance. Data quantization of ILC algorithms was investigated by Bu, Yin, and Liang for a class of linear systems based on a 2-D Roesser model. Ruan and Liu investigated the design of networked ILC algorithms for a class of nonlinear systems in the presence of stochastic output packet dropouts, while the paper by Shen, Zhang, and Xu discussed the design of networked ILC for a class of stochastic nonlinear systems with random data dropouts. The design of event-triggered ILC for multi-agent systems with the consideration of quantization was investigated by Zhang and Li.

The last group of papers presented various novel applications that utilize the concept of learning and adaptation in various applications, in which the repetitive feature is not needed. The paper by Xu, Chen and Chi presented the idea of using a dual extended Kalman Filter (DEKF) to estimate the vehicle states and the road friction coefficient. The recursive algorithms were proposed to "learn" the state and the unknown parameters in parallel, leading to good braking performance in an experimental brake test. An adaptive-supplementary unified power flow control algorithm, which uses a neural network based on a feedback linearization auto -regression av
Mehmood, Sajjad, and Bibi to provide effective low frequency oscillation damping in power systems. The paper by Farrokhi and Vatankhah utilized an adaptive neural network predictor to design a nonlinear adaptive model predictive control scheme for constrained systems with off-set free performance.

We hope that our readers will benefit from, and be motivated by, reading this issue.

Finally, the guest editors wish to thank Professor Li-Chen Fu, Editor-in-Chief of the Asian Journal of Control for providing us with this precious opportunity, and all the authors and the reviewers for their contributions to this special issue.

Guest Editors

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Ying Tan is an Associate Professor and Reader in the Department of Electrical and Electronic Engineering at The University of Melbourne. Dr Tan received her Bachelor's degree from Tianjin University, China, in 1995, and her PhD from the National University of Singapore in 2002. She joined McMaster University in 2002 as a postdoctoral fellow in the Department of Chemical Engineering. She joined the Department of Electrical and Electronic Engineering Department at the University of Melbourne in 2004. Dr Tan's main areas of research are nonlinear systems, on-line optimization and intelligent control systems. She has published 110 papers in journals and conferences and has attracted more than 2 million Australian dollars in research funding. She currently is Associate Editor for Systems and Control Letters, IEEE Transactions on Automatic Control, Unmanned Systems, Asian Journal of

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Chris Freeman is an Associate Professor in applied control within School of Electronics and Computer Science in University of Southampton, UK. He received the B.Eng. degree in electromechanical engineering and the Ph.D. degree in applied control from the University of Southampton, Southampton, U.K., in 2000 and 2004, respectively, and the B.Sc. degree in mathematical sciences from the Open University, Milton Keynes, U.K., in 2006. His research interests include iterative learning and repetitive control theory and their experimental application to industrial systems and biomedical engineering. He has published over 250 conference and journal articles and 2 books. He received the IEEE Control Systems Society Outstanding Journal Paper award in 2013 and Outstanding Journal Paper award from Elsevier in 2017. He has led the engineering component on large UK government funded grants which have developed a range of upper limb systems using robotic and Functional Electrical Stimulation (FES) technology that have each been trialled clinically with persons with stroke. In this area his current focus is on biomechanics, motor learning and control, non-contact sensing, electrode-array based FES, and wearable technology.

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Kira Barton is an Associate Professor and Miller Faculty Scholar in the Department of Mechanical Engineering at the University of Michigan. She received her B.Sc. in Mechanical Engineering from the University of Colorado at Boulder in 2001. She continued her education in mechanical engineering at the University of Illinois at Urbana-Champaign and completed her M.Sc. and Ph.D. degrees in 2006 and 2010, respectively. She held a postdoctoral research position at the University of Illinois from Fall 2010 until Fall 2011, at which point she joined the Mechanical Engineering Department at the University of Michigan at Ann Arbor. Kira conducts research in modeling, sensing, and control for applications in advanced manufacturing and robotics, with specializations in Iterative Learning Control, smart manufacturing and micro-additive manufacturing. Kira is the recipient of an NSF CAREER Award in 2014, 2015 SME Outstanding Young Manufacturing Engineer Award, the 2015 University of Illinois, Department of Mechanical Science and Engineering Outstanding Young Alumni Award, the 2016 University of Michigan, Department of Mechanical Engineering Department Achievement Award, and the 2017 ASME Dynamic Systems and Control Young Investigator Award.