Proposal for ISIE 2021 Tutorial

Title of Tutorial:

New Advances in Repetitive Control

Contact Information of Speakers:

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Background of Speakers:

Jinhua She
- Repetitive control
- Active disturbance control
- Assistive robotics

Lan Zhou
-Active disturbance rejection control
-Repetitive control
-Robust control

Jing Na
- Intelligent motion control for servo mechanisms, robotics and vehicles
- Adaptive control and parameter estimation for mechatronic systems
- High performance positioning methodology via repetitive control

Quan Quan
- Repetitive control
- Reliable Flight Control
- Swarm Control

Brief description of the tutorial (500 words max):

In control engineering practice, many systems exhibit repetitive behavior, such as a robot manipulator, a hard disk drive, and many other servo systems. Repetitive control has proven to be a useful control strategy for a system with a periodic reference input and/or disturbance signal. The distinguishing feature of repetitive control is that it contains a pure-delay positive-feedback loop, which is the internal model of a periodic signal. For a given periodic reference input, a repetitive controller gradually reduces the tracking error through repeated learning actions, which involves adding the control input of the previous period to that of the present period to regulate the present control input. This theoretically guarantees gradual improvement and finally eliminates any tracking error and provides very precise control, which is a chief characteristic of the human learning process.

From the standpoint of system theory, a repetitive control system is a neutral-type delay system. Asymptotic tracking and stabilization of the control system are possible only when the relative degree of a compensated plant is zero. To apply repetitive control to a strictly proper plant, which is the one that most control engineering applications deal with, the repetitive controller has to be modified by the insertion of a low-pass filter into the time-delay feedback line. The resulting system is called a modified repetitive control system. Since a modified repetitive controller is just an approximate model of a periodic signal, there exists a steady-state tracking error; that is, in a modified repetitive control system, the low-pass filter relaxes the stabilization condition but degrades the tracking precision. Thus, many studies have been devoted to solve the trade-off problem between stability and control performance in the design of a repetitive-control system.

In this tutorial, four speakers are going to explain the repetitive control method from the basic idea to the recently developed theoretical results and advanced applications. We first give the background and the basic idea of repetitive control. Next, we explain the configuration of a repetitive control system from the viewpoint of the internal model principle. Then, we show several methods of designing a repetitive controller. In particular, we explain some methods to solve the trade-off problem between stability and control performance. Finally, we present some application examples to show the validity of the method.

Biography:

Jinhua She received the Ph.D. degree from Tokyo Institute of Technology, Tokyo, Japan, in 1993 in control engineering. In 1993, he joined the School of Engineering, Tokyo University of Technology, where he is currently a professor with the Department of Mechanical Engineering. His research interests include the application of control theory, repetitive control, process control, Internet-based engineering education, and assistive robotics.

Dr. She's research interests include the applications of control theory, repetitive control, active disturbance rejection, process control, mobile-based engineering education, and assistive robotics. He has published more than 300 journal papers. His work has been cited 10831 times, and his h-index is 41 and i10-index is 144 (Google Scholar, January 8, 2021). He received the IFAC (International Federation of Automatic Control) Control Engineering Practice Paper Prize in 1999 (jointly with M. Wu and M. Nakano), and had been included in the list of Thomson Reuters' Highly Cited Researchers in 2012-2015.

Dr. She serves the Delegate of Cluster 4 of Technical Committees (containing 6 TCs) in IES and the Chair of IEEE IES Technical Committee on Human Factors. He is an Associated Editor of IEEE Transactions on Industrial Electronics, IEEE/ASME Transactions on Mechatronics, IEEE Journal of Emerging and Selected Topics in Industrial Electronics, etc.

Lan Zhou received the B.S. degree from Hunan Normal University, Changsha, China, in 1998, and the M.S. degree and the Ph.D. degree from Central South University, Changsha, China, in 2006 and 2011, respectively. From 2008 to 2010, she was a Joint Cultivation Doctoral Candidate of Japan and China. She is currently a Professor of Control Theory and Control Engineering with the School of Information and Electrical Engineering, Hunan University of Science and Technology, Xiangtan, China. Her current research interests include robust control, repetitive control, nonlinear control, and application for mechatronic systems.

Jing Na received the B.E. and Ph.D. degrees from the School of Automation, Beijing Institute of Technology, Beijing, China, in 2004 and 2010, respectively. From 2011 to 2013, he was a Monaco/ITER Postdoctoral Fellow with ITER Organization, Saint-Paul lez-Durance, France. From 2015 to 2017, he was a Marie Curie Fellow with the Department of Mechanical Engineering, University of Bristol, Bristol, U.K. Since 2010, he has been with the Faculty of Mechanical and Electrical Engineering, Kunming University of Science and Technology, Kunming, China, where he became a Professor in 2013. He has coauthored one monograph and more than 100 international journal and conference papers. His current research interests include intelligent control, adaptive parameter estimation, nonlinear control and applications for robotics, vehicle systems, and wave energy converter. Dr. Na received the Best Application Paper Award of IFAC ICONS 2013 and the Hsue-Shen Tsien Paper Award in 2017. He is currently an Associate Editor of the IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS and Neurocomputing. He has served as the Organization Committee Chair of DDCLS 2019 and the International Program Committee Chair of ICMIC 2017.

Quan Quan received the B.S. and Ph.D. degrees from Beihang University, Beijing, China, in 2004 and 2010, respectively. He was a research fellow in National University of Singapore from June 2011 to October 2011. Since 2013, he has been an Associate Professor with Beihang University, where he is currently with the School of Automation Science and Electrical Engineering. He was also a visiting professor of the University of Toronto in 2017 hosted by Professor W.M. Wonham. His research interests include repetitive control, reliable flight control, and swarm control.

He completed the first book about repetitive control for nonlinear systems entitled "Filtered Repetitive Control with Nonlinear Systems". Also, he published other two books on multicopter systems. He led his group to develop a performance evaluation website flyeval.com for multicopters and a simulation platform RflySim (rflysim.com).

Brief description of the intended audience

The intended audiences are researchers, engineers, and graduate students in the fields of electrical engineering, mechanical engineering, high-precision engineering, process control, rehabilitation sciences, health sciences, etc.

Support technical committee in IES (if any)

IEEE/IES Technical committee on Human Factors, Jinhua She, she@stf.teu.ac.jp.