Title of the Proposal: Recent Advances in Disturbance/Uncertainty Estimation and Attenuation (DUEA) Methods: Theory and Applications

- Presenter(s):

- Brief description:
Disturbances and uncertainties widely exist in most engineering systems and always bring adverse effects on control performance of the closed-loop systems. Design and analysis of nonlinear control systems under disturbances is an active research topic in control systems societies. Many advanced disturbance/uncertainty estimation and attenuation (DUEA) techniques have been developed to deal with systems in the presence of various disturbances and parametric uncertainties, for example stochastic control, output regulator control, \( H^\infty \) control, sliding mode control, disturbance observer based control (DOB), and active disturbance rejection control (ADRC), etc. DUEA shows many promising properties for practical applications including “flexibility for implementation”, “nominal performance recovery” and “prominent disturbance rejection ability”. Consequently, DUEA probably provides a stream of efficient solutions for improving the control performance of complex nonlinear systems. In this context, we wish to propose a tutorial session for the IECON 2020 entitled Recent Advances in Disturbance/Uncertainty Estimation and Attenuation (DUEA) Methods: Theory and Applications.

- Duration:
October 18, 2020, Afternoon tutorials (14:00-17:15)

- Outline:
Speaker 1: Prof. Shihua Li, IEEE Fellow, Southeast University, China

Title: Modeling, Analysis and Advanced Control with Applications for Mechatronic Systems

Abstract: For mechatronic systems, nonlinearities (frictions, backlash, saturation, etc.), complex internal dynamics, time-varying parameters, external disturbances and complex work tasks make control design a very challenging work. In this talk we will discuss on various advanced modeling, analysis and control techniques for mechatronic control systems. Compared with high gain control and integral control methods, disturbance estimation based control provides a different way to handle disturbance. Disturbance estimation based robust control method can effectively improve the disturbance rejection ability and ensure the robustness of closed-loop system. Some new research developments and results on this topic will be introduced. Considering the characteristics of mechatronic control system, several kinds of composite control design schemes based on disturbance estimation and compensation are presented with experimental verification results.

Speaker 2: Prof. Makoto Iwasaki, Dr. Eng., IEEE Fellow, Nagoya Institute of Technology, Japan

Title: Application of Disturbance Observer to Model and Compensation for Nonlinear Friction in Industrial Machines
Abstract: Fast-response and high-precision motion control is one of indispensable techniques in a wide variety of high performance mechatronic systems including micro and/or nano scale motion, such as data storage devices, machine tools, manufacturing tools for electronics components, and industrial robots, from the standpoints of high productivity, high quality of products, and total cost reduction. In those applications, the required specifications in the motion performance, e.g. response/settling time, trajectory/settling accuracy, etc., should be sufficiently achieved. In addition, the robustness against disturbances and/or uncertainties, the mechanical vibration suppression, and the adaptation capability against variations in mechanisms should be essential properties to be provided in the performance.

The tutorial talk presents an application of disturbance observer to model and compensation for nonlinear friction in varieties of industrial machines to realize the required fast and precision motion control performance, where a 2-degrees-of-freedom (2DOF) control framework is especially handled as one of practical and/or promising approaches. Actual issues and relevant solutions, i.e. how the friction modeling and compensation effectively work in the robust 2DOF control against known/unknown frictional disturbance, are presented as applications to industrial high precision positioning devices.

Speaker 3: Prof. Jun Yang, Southeast University, IEEE Senior Member, China
Title: Disturbance Observer Based-Control for Nonlinear Systems Under Mismatching Conditions

Abstract: In practical engineering, the disturbances and uncertainties are inevitable and bring various adverse influences to control performance of closed-loop systems. The existing control approaches suppress disturbances/uncertainties by means of high-gain and integral approaches. Disturbance observer based control (DOBC) provides an alternative solution to handle disturbances/uncertainties in real environments. The DOBC has two major advantages, the promising disturbance rejection performance and the effective nominal performance recovery. Most existing works focused on disturbances satisfying the so-called matched conditions. For the much more challenging problem, DOBC for nonlinear systems with mismatched disturbances, are still to be further investigated. In this presentation, the speaker will address their recent developments in DOBC for nonlinear systems under mismatching condition, in particular, on the disturbance compensation gain construction approach and the dynamic sliding surface design approach. Case studies on power converter, MAGLEV system, PMSM system, and aircraft systems are also discussed.

Speaker 4: Prof. Wen-Hua Chen, IEEE Fellow, Loughborough University, UK
Title: Gust Alleviation of Small Scale Unmanned Aerial Vehicles using Nonlinear Disturbance Observer Techniques

Abstract: Small scale unmanned aerial vehicles (UAVs) (e.g. mini or even smaller micro/nano UAVs) benefited from their small size and light weight are man-portable flying machines suitable for close-in support in contested, cluttered environment. They can find a wide range of applications in both military and civilian operations; such as urban overwatch or structure inspection. However, for the same reason, they are also vulnerable to various changes particularly gusts, payload and structure
changes. Gusts and the local airflow due to buildings and other structures may cause serious problems on flight stability and performance. Gust tolerance and alleviation is important for the survivability and the safe operation of this kind of UAV. This presentation will first introduce the nonlinear disturbance observer based control technique, where a nonlinear disturbance observer is designed to estimate external disturbance and the influence of uncertainty and then a compensation mechanism is designed based on the feedforward strategy. This technique is applied to gust alleviation of small scale UAVs where a nonlinear disturbance observer is developed to estimate the forces or torque applied on the aircraft due to wind/gust and integrated with a nominal nonlinear controller. Both helicopters and fixed wing aircraft will be considered in this presentation, with the support of video clips of indoor and outdoor flight tests.

Speaker 5: Prof. Lei GUO, Beihang University, IEEE Senior Member, China

Title: Enhanced Anti-disturbance Control for Multiple Disturbances: A Framework for Simultaneously Rejection and Attenuation

Abstract: Every complex system suffers from various disturbances, uncertainties and unknown variables, all of which in control context can be considered as disturbances. Multiple disturbances can results from internal, external disturbances and modelling errors as shown in [Guo & Cao, 2010]. In previous studies, all these disturbances are reduced into a single one, and different strategies including H-infinity, Kalman filtering, ADRC and DOBC can be presented to facing the corresponding reduced single disturbance. It is insufficient and sometime very dangerous since a minor disturbance may result in disaster like the butterfly effect. Another interesting point will be discussed from the view of medicine and health since disturbances and faults for a system like diseases for a body. As such, the idea of composite hierarchical anti-disturbance control (CHADC) has been addressed for multiple disturbance systems from [Guo & Chen 2005]. In this presentation, we wish to furtherly address the framework of CHADC which include the disturbance characterization, analysis, estimation, simultaneously rejection and attenuation. With the CHADC framework, it is shown that one may deal with disturbances, faults and uncertainties in a unified way. Especially, the enhanced anti-disturbance control (EADC) method as a special one of CDADC will be introduce which effectively combines ADRC and DOBC together. Some engineering applications on satellites and UAVs will be given to shown their good performance.

-Brief CV:

Photo, name, email, and short CV

Organizer 1: Shihua Li , Southeast University, China, IEEE Fellow, IES Member
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Shihua Li earned his B.Eng., M.Sc. and Ph.D. degrees in control science and engineering from Southeast University, Nanjing, China in 1995, 1998 and 2001, respectively. Since 2001, he has been with School of Automation, Southeast University, now he is a full professor. He has published 2 books, over 180 international journal papers with 16000+ citations (Google Scholar), covering modeling, analysis and advanced control of mechatronic systems. He is the corecipient of 4 prize paper awards. He serves as associate editors of IEEE Transactions on Industrial Electronics,
The 46th Annual Conference of the IEEE Industrial Electronics Society
October 18-21, 2020, Marina Bay Sands Expo and Convention Centre
Singapore

International Journal of Robust and Nonlinear Control, IET Control Theory and Applications, etc. He is chair of IEEE IES Nanjing Chapter and vice chair of IEEE CSS Nanjing, secretary general of Jiangsu Association of Automation. He is a member of Technical Committee on Electrical Machines, Motion Control of the IEEE IES, respectively. He is a member of the Technical Committee on Control Theory of Chinese Association of Automation. He was the general chair of the 2019 IEEE Workshop on ADRC, the program chair of the 2016 IEEE International Workshop on Variable Structure Systems. He is one of Clarivate Analytics Highly Cited Researchers (Engineering) all over the world in 2017-2019. He is a Fellow of IEEE and IET.

Organizer 2: Makoto Iwasaki, Nagoya Institute of Technology, Japan, IEEE Fellow, IES Member
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Makoto Iwasaki received the B.S., M.S., and Dr. Eng. degrees in electrical and computer engineering from Nagoya Institute of Technology, Nagoya, Japan, in 1986, 1988, and 1991, respectively. Since 1991, he has been with the Department of Computer Science and Engineering, Nagoya Institute of Technology, where he is currently a Professor at the Department of Electrical and Mechanical Engineering. As professional contributions of the IEEE, he has been an AdCom member of IEEE Industrial Electronics Society (IES) in term of 2010 to 2019, a Technical Editor for IEEE/ASME TMech from 2010 to 2014, an Associate Editor for IEEE TIE since 2014, a Management Committee member of IEEE/ASME TMech (Secretary in 2016 and Treasurer in 2017), a Co-Editors-in-Chief for IEEE TIE since 2016, an IEEE/IES Fellows Committee member since 2017, a Vice President for Planning and Development in term of 2018 to 2019, and a Medal Committee member for IEEE Medal in Power Engineering in term of 2019-2019, respectively. He is IEEE fellow class 2015 for "contributions to fast and precise positioning in motion controller design". He has received the Best Paper Award of Trans of IEEE Japan in 2013, the Best Paper Award of Fanuc FA Robot Foundation in 2011, the Technical Development Award of IEE Japan in 2017, the Nagamori Awards in 2017, the Ichimura Prize in Industry for Excellent Achievement of Ichimura Foundation for New Technology in 2018, and the Technology Award of the Japan Society for Precision Engineering in 2018, respectively. His current research interests are the applications of control theories to linear/nonlinear modeling and precision positioning, through various collaborative research activities with industries. Dr. Iwasaki is a member of the Institute of Electrical Engineers of Japan and the Japan Society for Precision Engineering.

Organizer 3: Jun Yang, Southeast University, China, IEEE Senior Member, IES Member
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Jun Yang received his B.Sc. degree in the Department of Automatic Control from Northeastern University, Shenyang, China in 2006. In 2011, he received
his Ph.D. degree in control theory and control engineering from School of Automation, Southeast University, Nanjing, China, where he is currently an Associate Professor. His research interests include disturbance estimation and compensation, advanced control theory and its application to flight control systems and motion control systems.

- Organizer 4: Wen-Hua Chen, Loughborough University, UK, IEEE Fellow, IES Member
  
  Wen-Hua Chen received the M.Sc. and Ph.D. degrees from Northeast University, Shenyang China, in 1989 and 1991, respectively. He is currently a Professor with the Department of Aeronautical and Automotive Engineering, Loughborough University, Loughborough, UK. His research interests include the development of advanced control strategies and their applications in aerospace and automotive engineering. Currently, much of his work has also involved in the development of Unmanned Autonomous Intelligent Systems. He is a Fellow of IEEE.

- Organizer 5: Prof. Lei GUO, Beihang University, China, IEEE Senior Member, IES Member
  
  Lei Guo is a Distinguished Professor of Beihang University, Beijing. He received the B.S. and M.S. degrees from Qufu Normal University in 1988 and 1991, respectively, and the Ph.D. from Southeast University in 1997. From 1997 to 1999, he was a Postdoctoral Fellow with Southeast University. From 1999 to 2004, he has worked with IRCCyN at Nantes, Loughborough University, and the University of Manchester Institute of Science and Technology (UMIST), respectively. From 2004 to 2006, he was a Professor of Southeast University, where he visited Okayama Prefectural University as JSPS fellow for 6 months. From 2006 to now, he is a Professor of Beihang University, Beijing, China. He is an Awarder of the National Science Fund for Distinguished Young Scholars of China and the Changjiang Distinguished Professor of the Ministry of Education of China. He obtained the State Natural Science Award of China in 2013 and State Technological Invention Award of China in 2018 for his service and achievements both in anti-disturbance control theory and in engineering applications. He has more than 220 papers, 80 patents, and 3 monographs which focus on anti-disturbance control, stochastic systems, fault detection, filter design, and nonlinear control with their applications.
- Relevant publications:


