FINAL PROGRAM and BOOK OF ABSTRACTS

2022 IEEE 11th Data Driven Control and Learning Systems Conference (DDCLS'22)

Emeishan, Sichuan, China

August 3–5, 2022

Sponsored by

Technical Committee on Data Driven Control, Learning and Optimization, Chinese Association of Automation

Qingdao University

Locally Organized by

Southwest Jiaotong University

Co-Sponsored by

IEEE Beijing Section

Chengdu Association of Automation

IEEE Catalog Number: CFP22HAG-USB
ISBN: 978-1-6654-9674-2

CONTENTS

Organizing Committee

General Chairs:
Zhongsheng Hou, Qingdao University, China
Xiaoyun Feng, Southwest Jiaotong University, China

General Co-Chairs:
Chenghong Wang, Chinese Association of Automation, China
Xiongxiong He, Zhejiang University of Technology, China
Weirong Chen, Southwest Jiaotong University, China

Organizing Committee Chairs:
Jing Wang, North China University of Technology, China
Deqing Huang, Southwest Jiaotong University, China

Organizing Committee Co-Chairs:
Darong Huang, Chongqing Jiaotong University, China
Lei Ma, Southwest Jiaotong University, China
Xiaoqiong He, Southwest Jiaotong University, China

Technical Program Committee Chairs:
Mingxuan Sun, Zhejiang University of Technology, China
Zengqiang Chen, Nankai University, China

Regional Chairs:
Ying Yang, Peking University, China
Xiao He, Tsinghua University, China
Wenchao Xue, Academy of Mathematics and Systems Science, CAS, China
Xiaodong Li, Sun Yat-sen University, China
Jia Shi, Xiamen University, China
Weidong Zhang, Shanghai Jiao Tong University, China
Fei Qiao, Tongji University, China
Li Jia, Shanghai University, China
Kuangrong Hao, Donghua University, China
Fei Liu, Jiangnan University, China
Zhiqiang Ge, Zhejiang University, China
Yi Liu, Zhejiang University of Technology, China
Chunjie Zhou, Huazhong University of Technology, China
Chunhua Yang, Central South University of Technology, China
Yi Chai, Chongqing University, China
Xiao'e Ruan, Xi'an Jiaotong University, China
Junmin Li, Xidian University, China
Haisheng Yu, Qingdao University, China
Zhigang Lu, Yanshan University, China
Zhanshan Wang, Northeastern University, China
Yantao Tian, Jilin University, China
Shen Yin, Harbin Institute of Technology, China
Jun Zhao, Dalian University of Technology, China
Zhiqiang Zuo, Tianjin University, China
Xisheng Dai, Guangxi University of Science and Technology, China
Yuan Yao, National Tsing Hua University, Taiwan, China

Committee Members:
Members of Technical Committee on Data Driven Control, Learning and Optimization and Invited Experts

Invited Session Chairs:
Dongbin Zhao, Institute of Automation, CAS, China
Senping Tian, South China University of Technology, China
Yanjun Liu, Liaoning University of Technology, China
Ruizhuo Song, University of Science & Technology Beijing, China
Li Wang, North China University of Technology, China
Qinglai Wei, Institute of Automation, CAS, China
Weiwei Che, Qingdao University, China

	Zhijian Ji, Qingdao University, China Ying Zheng, Huazhong University of Technology, China Tianjiang Hu, Sun Yat-sen University, China Xiangyang Li, South China University of Technology, China Zhengguang Wu, Zhejiang University, China
Subject Session Chairs:	Zhihuan Song, Zhejiang University, China Yongchun Fang, Nankai University, China Xin Xu, National University of Defense Technology, China
Panel Discussion Chairs:	Hongye Su, Zhejiang University, China Qunxiong Zhu, Beijing University of Chemical Technology, China Zengguang Hou, Institute of Automation, CAS, China Changhua Hu, Rocket Force University of Engineering, China
Poster Session Chairs	Xuhui Bu, Henan Polytechnic University, China Wenjun Xiong, Southwestern University of Finance and Economics, China Wei Ai, South China University of Technology, China Xuefang Li, Sun Yat-sen University, China
International Affairs Chairs:	Danwei Wang, Nanyang Technological University, Singapore Chiang-Ju Chien, Huafan University, Taiwan, China Zhi-Qiang Gao, Cleveland State University, USA Youqing Wang, Beijing University of Chemical Technology, China Chunhui Zhao, Zhengjiang University, China
Finance Chairs:	Shangtai Jin, Beijing Jiaotong University, China Rongmin Cao, Beijing Information Science and Technology University, China
Publication Chairs:	Mengqi Zhou, IEEE Beijing Section, China Dong Shen, Renmin University of China, China
Editorial Chairs:	Ronghu Chi, Qingdao University of Science & Technology, China Deyuan Meng, Beihang University, China Shan Liu, Zhejiang University, China
Publicity Chairs:	Long Cheng, Institute of Automation, CAS, China Hongyi Li, Guangdong University of Technology, China Jing Na, Kunming University of Science and Technology, China Shuguo Yang, Qingdao University of Science & Technology, China Na Qin, Southwest Jiaotong University, China
Secretary General:	Chenkun Yin, Beijing Jiaotong University, China
Secretary:	Liangcheng Cai, Southwest Jiaotong University, China

Welcome Message from General Chairs

Zhongsheng Hou
General Chair of DDCLS'22

Xiaoyun Feng
General Chair of DDCLS'22

Dear Friends and Colleagues,

On behalf of the Organizing Committee, it is our greatest pleasure to welcome you to the 2022 IEEE 10th Data Driven Control and Learning Systems Conference (DDCLS'22), which is organized by Technical Committee on Data Driven Control, Learning and Optimization (DDCLO), Chinese Association of Automation and Qingdao University, locally organized by Southwest Jiaotong University and Chengdu Association of Automation, and sponsored by IEEE Beijing Section. The conference is held at Le Meridien Emei Mountain Resort, Emeishan, Sichuan Province, China, August 3–5, 2022.

Data driven control and learning systems, together with model-based control methods for the target of forming the complete control theory, is an emerging hot research area in the field of automation engineering and in systems & control. It focuses on all the issues of control, learning and optimization for the plants whose models are unavailable. Although the study on data driven control and learning is still in the embryonic stage, it has attracted a great amount of attention within the systems and control community, such as the special issues published in the top journals: *ACTA AUTOMATICA SINICA* (2009), *IEEE Transactions on Neural Networks* (2011), *Information Sciences* (2013), *IEEE Transactions on Industrial Informatics* (2013), *IEEE Transactions on Industrial Electronics* (2015, 2017), and *IET Control Theory & Applications* (2015, 2016). Further, the problems in the data driven control and learning systems would be fundamental challenges in the coming age of the *Internet of Things*, *Cyber-Physical Systems*, *Industry 4.0*, *China Manufacturing 2025*, and *Artificial Intelligence 2.0* under the big data environment, which is already on our road ahead but beyond the traditional systems & control methods.

As an inheritance of previous ten conferences, DDCLS'22 continues to attract broad interest throughout the world, with the submission of 314 papers. This reflects the increasing interest in our field, and meanwhile creates a difficult workload in evaluating the papers and organizing a cohesive program. We are fortunate

to have an exceptional Technical Program Committee (TPC) that sorted through the evaluations and integrated the individual submissions into the final technical program described in the proceedings. We want to thank our Organizing Committee for their invaluable assistance in arranging the diverse offerings at the conference, from registration and local arrangements to technical programs. Last but not least, we would like to express our deep appreciation to Southwest Jiaotong University for their great support.

The Technical Program Committee has assembled a comprehensive technical program that covers a broad spectrum of topics in data driven control and learning systems. The DDCLS'22 technical program comprises 19 regular sessions, 15 invited sessions, 1 best paper award session and 2 poster sessions. Besides the technical sessions, the highlights of the DDCLS'22 are the keynote addresses given by world-class level scholars, Prof. Huaguang Zhang from China, Prof. S. Joe Qin from Hong kong, China, Prof. Shibin Gao from China, and the distinguished lectures given by active young scholars. They are Prof. Xiaowo Wang, Prof. Wenwu Yu, Prof. Yang Tang, Prof. Honggui Han, Prof. Ping Zhou, Prof. Yi Liu, Prof. Ronghu Chi and Prof. Weiwei Che, all from China. During the conference, a Pre-Conference Workshop with the theme of intelligent railway transportation system is also held for the conference participants. These activities provide high quality research and professional interactions on the subject of data-driven control, artificial intelligence, automation and applications in various industries. We sincerely appreciate all the contributors, especially the keynote address speakers, distinguished lecture speakers, invited session organizers, and session chairs for their tremendous efforts towards a top-quality conference.

We also want to thank the young lovely volunteers who have made this conference possible. Without you, the monumental task ahead of us for organizing this conference would be significantly beyond our capabilities.

you have a wonderful and fascinating stay in Emeishan, Sichuan Province, China, and enjoy the colorful scenery and magic foods.

Best wishes

Zhongsheng Hou
General Chair of DDCLS'22

Xiaoyun Feng
General Chair of DDCLS'22

Message from Technical Program Chairs

Mingxuan Sun
Technical Program Chair

Zengqiang Chen
Technical Program Chair

Dear Friends and Colleagues,

On behalf of the Technical Program Committee, it is our great honor to welcome you to the 2022 IEEE 11th Data Driven Control and Learning Systems Conference (DDCLS'22) in Emeishan, China.

The annual event of DDCLS has proven to be one of the excellent forums for scientists, researchers, engineers, and industrial practitioners to present and discuss the latest technological advancements as well as future directions and trends in Data Driven Control, Learning and Optimization, and to set up useful links for their works. DDCLS'22 has received enthusiastic responses with a total of 314 submissions. All the submissions had been processed by the Technical Program Committee. All committee members worked professionally, responsibly, and diligently. Besides evaluations from reviewers, each member also provided his/her own assessments on the assigned papers, so as to ensure that only high-quality papers would be accepted. Their commitment and hard work have enabled us to put together a very solid proceeding for our conference. The proceeding includes 245 accepted papers and 30 invited extended abstracts which are divided into 35 oral sessions and 2 poster sessions for presentation to show the latest academic development in data driven control and learning systems.

Ahead of the parallel technical sessions, we will have three keynote talks to be delivered by eminent scientists. These lectures will address the state-of-the-art developments and leading-edge research topics in both theory and applications in Data Driven Control, Learning and Optimization. We are most honored to have Prof. Huaguang Zhang (Northeastern University), Prof. S. Joe Qin (City University of Hong Kong), and Prof. Shibin Gao (Southwest Jiaotong University) as the keynote address speakers. Besides, we are very fortunate to have the distinguished lectures given by the five outstanding young scholars, Prof. Xiaowo Wang (Tsinghua University), Prof. Wenwu Yu (Southeast University), Prof. Yang Tang (East China University of Science and Technology), Prof. Honggui Han (Beijing University of Technology), Prof. Ping Zhou (Northeastern University), Prof. Yi Liu (Zhejiang University of Technology), Prof. Ronghu Chi (Qingdao University of Science and Technology) and Prof. Weiwei Che (Qingdao University). DDCLS'22 is also rich in other academic activities, such as Pre-Conference Workshop. Five distinguished scholars will present their new research findings in the field of intelligent railway transportation system. We are confident that their presence would undoubtedly act prestige to the conference. We would like to express our sincere

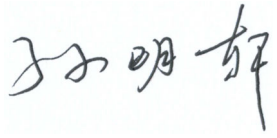
appreciations to all of them for their enthusiastic contributions and strong supports to DDCLS'22.

To promote the development of the society of Data Driven Control, Learning and Optimization, the highest quality papers will be rewarded with the Best Paper Award at DDCLS'22. Based on reviewers' comments and nominations as well as the evaluations of Technical Program Committee members, 22 papers were selected for the consideration of the award by the Best Paper Award Committee. These papers were sent to some distinguished experts in the relevant areas for additional evaluations in a double-blind manner. Based on their comments and recommendations, five papers were shortlisted as the finalists for the award. During the conference, the oral presentations of the five finalists will be further assessed by the DDCLS'22 Best Paper Award Committee. The winner of the "DDCLS Best Paper Award" will be selected by the committee after assessing the oral presentations. Furthermore, the interactive presentations of 66 papers in 2 poster sessions will be assessed by the DDCLS'22 Best Poster Award Committee during the conference, and one or two papers will be conferred to the "DDCLS Best Poster Award" by the committee after assessing the interactive presentations.

A U-disk containing the PDF files of all papers scheduled in the program and an Abstract Book will be provided at the conference to each registered participant as part of the registration material. The official conference proceedings will be published by the IEEE and included in the IEEE Xplore Database.

On behalf of the Technical Program Committee, we would like to thank all reviewers for giving time and expertise to provide comments, which are contributive to the Committee in making a fair decision on the acceptance/rejection of each paper. Thanks also go to the dedication, diligence, and commitments of the Invited Session Chairs Prof. Dongbin Zhao, Prof. Senping Tian, Prof. Yanjun Liu, Prof. Ruizhuo Song, Prof. Li Wang, Prof. Qinglai Wei, Prof. Zhijian Ji, Prof. Weiwei Che, Prof. Ying Zheng, Prof. Tianjiang Hu, Prof. Xiangyang Li and Prof. Zhengguang Wu, Subject Session Chairs Prof. Zhihuan Song, Prof. Yongchun Fang and Prof. Xin Xu, and all the members of the Technical Program Committee. We would like to gladly acknowledge the technical sponsorship provided by the Organizing Committee of DDCLS'22 and Technical Committee on Data Driven Control, Learning and Optimization, Chinese Association of Automation. We also convey our heartfelt thanks to friends, colleagues, and families who have helped us in completing the technical program directly or indirectly. Last but not least, we are grateful for the strong and enthusiastic support of all delegates, especially those old faces around the world.

We do hope that you will find your participation in DDCLS'22 in Emeishan is really stimulating, rewarding, enjoyable, and memorable.



Mingxuan Sun
Technical Program Chair

Zengqiang Chen
Technical Program Chair

Keynote Address

Keynote Address 1

Self-learning Optimal Control for Power Systems by Using ADP: Recent Results and Applications

Prof. Huaguang Zhang
Northeastern University, China

Thursday, Aug. 4, 2022
08:30-09:30
Grand Ballroom (大宴会厅)

Abstract

As is known, it is often computationally untenable to run dynamic programming due to "curse of dimensionality". Adaptive dynamic programming (ADP) is a powerful tool in solving the optimal control problems of complex nonlinear systems based on the principle of optimality and neural networks. In this talk, the self-learning optimal control issues will be addressed as follows: 1) The fundamental theory and recent development of ADP-based optimal control; 2) The event-triggered ADP for multi-player games is proposed in an on-line fashion, which can remove the requirement of control information in the triggering condition; 3) Considering the practical applications, we further study the optimal control of the multi-area power system and hybrid wind/solar systems to solve the accurate current sharing and realize the voltage and frequency regulation. Some examples are provided to show that the proposed method has good robustness to the uncertainty and unmodelled dynamics of the power systems.

Biography

Huaguang Zhang received the Ph.D. degree from Southeast University, Nanjing, China, in 1991. From 1992 to 1994, he did his postdoctoral research at Northeastern University, Shenyang, China. He has been with Northeastern University since 1991, and is currently as a Full Professor and Ph.D. advisor. He has authored and coauthored over 300 journal and conference papers, four monographs and co-invented more than 50 patents. He has been severing as an associate Editor of Automatica since 2008, an associate Editor of IEEE Transactions on neural networks since 2010, an associate Editor of IEEE Transactions on Cybernetics since 2007, an associate editor of Neurocomputing since 2007. In addition, he is a fellow of IEEE, the former E-letter Chair, and the former Chair of Adaptive Dynamic Programming & Reinforcement Learning Technical Committee in IEEE Computational Intelligence Society. Besides those he has been a member of the Neural Systems and Applications (NSA) Committee of IEEE Circuits and Systems Society, a member of the Blind Signal Processing (BSP) Committee of IEEE Circuits and Systems Society, a member of the Technical Committee on Computational Intelligence of the Systems, Man, and Cybernetics Society since 2007. He was awarded the Outstanding Youth Science Foundation Award from the National Natural Science Foundation Committee of China in 2003. He was named the Cheung Kong Scholar by the Education Ministry of China in 2005. He is a recipient of the IEEE Transactions on Neural Networks Outstanding Paper Award (2012) and Andrew P. Sage Best Transactions Paper Award (2015) with IEEE SMC Society. His current research interests include Adaptive Dynamic Programming, Fuzzy System Theory, Fuzzy Control, Neural Network-Based Control, Adaptive Control, Complex Industry Process Automation, Electric Power System Automation, Motor Driving System Automation, Integrated Energy System Optimization.

Keynote Address 2

Dynamic Latent Feature Learning and Troubleshooting of Manufacturing Processes

Prof. S. Joe Qin
City University of Hong Kong, China

Thursday, Aug. 4, 2022
10:00-11:00
Grand Ballroom (大宴会厅)

Abstract

Sustained and unsettled dynamics in real-time data from manufacturing processes often indicate troubled control performance or equipment malfunctioning. In this talk, we present a latent dynamic feature extraction framework to achieve simultaneously dimension reduction and latent dynamic modeling. The dynamic latent features are enforced to be orthogonal and used for troubleshooting process anomalies. Composite loadings and weights are given to analyze root causes and contributions to a dynamic feature of interest. The dynamic embedded feature analytics (DELFA) approach to process troubleshooting is introduced and demonstrated on several industrial manufacturing processes with great successes.

Biography

Dr. S. Joe Qin is currently Chair Professor, Dean of the School of Data Science, and Director of Hong Kong Institute for Data Science at City University of Hong Kong. In his prior career he was the Fluor Professor at the Viterbi School of Engineering of the University of Southern California, Endowed Professor at the University of Texas at Austin, and Principal Engineer at Emerson Process Management. He was Cheung Kong Visiting Professor with Tsinghua University from 2006 to 2009.

Dr. Qin is a Fellow of the U.S. National Academy of Inventors, the International Federation of Automatic Control (IFAC), AIChE, and IEEE. He is a recipient of the U.S. National Science Foundation CAREER Award, the 2011 Northrop Grumman Best Teaching award at USC Viterbi School of Engineering, the DuPont Young Professor Award, Halliburton/Brown & Root Young Faculty Excellence Award, NSF-China Outstanding Young Investigator Award, and IFAC Best Paper Prize for a model predictive control paper published in Control Engineering Practice. He has served as Senior Editor of Journal of Process Control, Editor of Control Engineering Practice, Member of the Editorial Board for Journal of Chemometrics, and Associate Editor for several journals. He has published over 400 international journal papers, book chapters, conference papers and/or presentations. He received over 34,000 Google Scholar citations with an h-index of 79. Dr. Qin's research interests include data analytics, machine learning, process monitoring, fault diagnosis, model predictive control, system identification, smart manufacturing, and predictive maintenance.

Keynote Address 3

高速铁路牵引供电系统故障预测与健康管理

Prof. 高仕斌
Southwest Jiaotong University, China

Thursday, Aug. 4, 2022
11:00-12:00
Grand Ballroom (大宴会厅)

Abstract

中国高速铁路运营里程规模大、运行速度高，安全稳定运行意义重大。本报告主要介绍中国高速铁路牵引供变电设备、受电弓-接触网的检测监测方法、功能部署与系统；高速铁路牵引供变电设备、受电弓-接触网的故障预测与健康状态评估方法与系统。

Biography

高仕斌，1964年11月出生，西南交通大学教授、国家轨道交通电气化与自动化工程技术研究中心主任、高速铁路技术攻关组核心成员、川藏铁路工程建设专家咨询委会成员。曾4次获得国家科技进步二等奖（2项排名第1、2项排名第2）、11次获得省部级科学技术特等奖/一等奖。曾获百千万国家级人选、何梁何利科学技术进步奖和詹天佑大奖。

Distinguished Lecture

Distinguished Lecture 1

De novo Design of Gene Regulatory Codes Using AI

Prof. Xiaowo Wang
Tsinghua University, China

Thursday, Aug. 4, 2022
13:10-13:45
Grand Ballroom1(大宴会厅 1)

Abstract

DNA is the programming language of life. Gene expression level is determined by the regulatory information encoded in DNA sequence elements like promoters. Obtaining new genetic regulatory elements has tremendous usage in metabolic engineering and synthetic biology applications. Theoretically, there are as many as 4100 possible combinations even for a 100 base pair DNA sequence. Only part of them are biocompatible and naturally occurring genomes make up a very small subset. To explore the high dimensional space of potential sequences, we reported a novel machine learning framework for de novo gene regulatory sequence design. The model, which was guided by sequence features learned from natural DNA sequences, could capture long range dependencies between nucleotides at different positions and design novel synthetic elements in silico. The model designed gene promoters were experimentally demonstrated to be functional in vivo, and a number of them showed comparable or even higher activities than most active natural promoters and their strongest mutants. Many of these generated sequences showed low global sequence similarity to the wild type genome, and noncanonical motifs were found in highly expressed promoters. Our work provided new insights into de novo gene regulatory element design, indicating the potential ability of AI to obtain new optimized genetic elements.

Biography

Xiaowo Wang is currently a full professor at the Department of Automation Tsinghua University. He received his bachelor's degree of engineering and Ph.D. in bioinformatics from Tsinghua University. He was a visiting student in Cold Spring Harbor laboratory in 2007, and a Tang Distinguished Scholar in Quantitative Biology Institute QB3 of UC Berkeley in 2012. He joined the faculty of Tsinghua University since 2008. His lab aims to bring machine learning and biology approaches together to understand gene regulation networks systematically, and guide the quantitative design of synthetic biological systems for precise medicine applications. He has published 50+ peer-reviewed papers in journals including PNAS, Cell reports, NAR, Bioinformatics etc., and his work has been cited more than 7,000 times. He is a receipt of the National Natural Science Fund for Excellent Young Scholars of China in 2013, and Young Scientists Awards of Chinese Association of Automation in 2019.

Distinguished Lecture 2

Networked Collective Intelligence in Intelligent Transportation System

Prof. Wenwu Yu
Southeast University, China

Thursday, Aug. 4, 2022
13:45-14:20
Grand Ballroom1(大宴会厅 1)

Abstract

In this talk, the multi-agent collective behaviors and some of their potential applications are briefly reviewed. In particular, intelligent transportation system is studied based on networked collective intelligence. We first introduced the 5G technology about networked automatic drive. Then, we discussed several critical problems about network construction, prediction of network traffic, and traffic signal control, which forms the cooperative intelligent system. We also provided some future studies in this topic.

Biography

Wenwu Yu received the B.Sc. degree in information and computing science and M.Sc. degree in applied mathematics from the Department of Mathematics, Southeast University, Nanjing, China, in 2004 and 2007, respectively, and the Ph.D. degree from the Department of Electronic Engineering, City University of Hong Kong, Hong Kong, China, in 2010. Currently, he is the Founding Director of Laboratory of Cooperative Control of Complex Systems and the Deputy Associate Director of Jiangsu Provincial Key Laboratory of Networked Collective Intelligence, an Associate Dean in the School of Mathematics, and a Full Professor with the Endowed Chair Honor in Southeast University, China.

Dr. Yu held several visiting positions in Australia, China, Germany, Italy, the Netherlands, and the USA. His research interests include multi-agent systems, complex networks and systems, disturbance control, distributed optimization, neural networks, game theory, cyberspace security, smart grids, intelligent transportation systems, big-data analysis, etc.

Dr. Yu severs as an Editorial Board Member of several flag journals, including IEEE Transactions on Circuits and Systems II, IEEE Transactions on Industrial Informatics, IEEE Transactions on Systems, Man, and Cybernetics: Systems, Science China Information Sciences, Science China Technological Sciences, ACTA AUTOMATICA SINICA, etc.

He was listed by Clarivate Analytics/Thomson Reuters Highly Cited Researchers in Engineering in 2014 -2021. He publishes about 100 IEEE Trans. journal papers with more than 20,000 citations. Moreover, he was awarded a National Natural Science Fund for Excellent Young Scholars in 2013, the National Ten Thousand Talent Program for Young Top-notch Talents in 2014, and the Cheung Kong Scholars Programme of China for Young Scholars in 2016 and for Scholars in 2020. Dr. Yu is also the recipient of the Second Prize of State Natural Science Award of China in 2016.

Distinguished Lecture 3

Perception and Decision-Making in Autonomous Intelligent Systems

Prof. Yang Tang
East China University of Science and Technology, China

Thursday, Aug. 4, 2022
14:20-14:55
Grand Ballroom1(大宴会厅 1)

Abstract

In this talk, we will review our recent advances in perception and decision-making in autonomous intelligent systems. We will first report our results in unsupervised depth estimation via deep learning in dynamic environment. Then, we will show our results adapted to different extreme conditions like night, rainy night and snow days. After giving our results in perception of complex environment, we will also present our results in decision-making of UAV for aggressive flight and collision avoidance. Finally, some concluding remarks will be provided.

Biography

Yang Tang received the B.S. and Ph.D. degrees in electrical engineering from Donghua University, Shanghai, China, in 2006 and 2010, respectively. From 2008 to 2010, he was a Research Associate with The Hong Kong Polytechnic University, Hong Kong. From 2011 to 2015, he was a Post-Doctoral Researcher with the Humboldt University of Berlin, Berlin, Germany, and with the Potsdam Institute for Climate Impact Research, Potsdam, Germany. Since 2015, he has been a Professor with the East China University of Science and Technology, Shanghai. His current research interests include distributed estimation/control/optimization, cyber-physical systems, hybrid dynamical systems, computer vision, reinforcement learning and their applications.

Prof. Tang was a recipient of the Alexander von Humboldt Fellowship and has been the ISI Highly Cited Researchers Award by Clarivate Analytics from 2017. He is a Senior Board Member of Scientific Reports, an Associate Editor of IEEE Transactions on Neural Networks and Learning Systems, IEEE Transactions on Emerging Topics in Computational Intelligence, IEEE Transactions on Circuits and Systems I: Regular Papers and IEEE Systems Journal, etc.

Distinguished Lecture 4

Intelligent Identifying and Self-healing Control for Municipal Wastewater Treatment

Prof. Honggui Han
Beijing University of Technology, China

Thursday, Aug. 4, 2022
14:55-15:30
Grand Ballroom1(大宴会厅 1)

Abstract

As an effective way to realize water resources recycling, the municipal wastewater treatment is the significant strategy of national comprehensive utilization of water resources. Meanwhile, the intelligent identifying and self-healing control method for municipal wastewater treatment is the core technology to ensure the safe and efficient operating conditions. This report will discuss the intelligent identifying and self-healing control technology for municipal wastewater treatment based on data and knowledge, and will design the intelligent identifying system to solve the problems of frequent occurrence of abnormal conditions, effluent exceed the standard, and so on. The main topics are as follows: the data mining and knowledge inference methods will be developed to realize the online identification of abnormal operating conditions. The intelligent warning methods, based on the data and knowledge, will be proposed for the abnormal conditions. Moreover, the intelligent warning model will be established to realize the abnormal conditions online. Furthermore, the self-healing control theory will be discussed to achieve the effective suppression of abnormal mode. Finally, an intelligent identifying system which will be designed and used in the real municipal wastewater treatment plants, to ensure the emissions compliance and reduce the incidence of abnormal conditions.

Biography

Honggui Han, professor, president of Engineering Research Center of Ministry of Education, vice president of Beijing Key Laboratory, vice president of Graduate School, Beijing University of Technology. He has attended the national natural science foundation of outstanding youth science foundation, Beijing outstanding young scientist, young elite scientists sponsorship program by Chinese association for science and technology, and so on. Moreover, he is the director of the committee of popular science work of Chinese artificial intelligence society, the director of Beijing Institute of artificial intelligence, IEEE senior member, and so on. Furthermore, he is the editor of many international journals and the secretary of many international and domestic academic conferences.

He has obtained many innovative methods and practical technologies in the aspect of intelligent modeling, self-organizing fuzzy control and multi-objective intelligent optimization. Moreover, he has solved many bottleneck problems in urban wastewater treatment industry. He has attended more than 10 projects, including the national key research and development project, the key project of national natural science foundation of china, the national natural science foundation of outstanding youth science foundation, the Beijing science and technology projects, as well as other national and provincial projects. He has published 85 academic papers in IEEE Transactions on Industrial Electronics, IEEE Transactions on Cybernetics, Automatica and other journals, which are cited more than 1000 times (SCI index). Moreover, he has written 2 books, applied 65 patents (authorized 45), authorized 43 software copyrights. Finally, he has won many honours, such as the 2nd prize of national science and technology progress award, the 1st prize of Chinese artificial intelligence science and technology progress award, and so on.

Distinguished Lecture 5

Data-Driven Robust Modeling and Learning Modeling of Ironmaking Blast Furnace

Prof. Ping Zhou
Northeastern University, China

Thursday, Aug. 4, 2022
15:40-16:15
Grand Ballroom1(大宴会厅 1)

Abstract

Blast furnace automation is a hot and difficult research topic in the field of metallurgical engineering and industrial automation. Aimed at the problems of imperfect data quality and nonlinear dynamic time-variation in the blast furnace ironmaking process which is difficult to model with conventional methods, this talk introduces some of the team's recent work on data-driven blast furnace ironmaking process modeling. My talk focusses on the robust modeling methods and online learning modeling methods for reliable quality prediction, as well as the subspace identification modeling method for quality control.

Biography

Ping Zhou is a professor and doctoral tutor of Northeastern University. He was selected as the top young talents in the National "Ten Thousand People Program", "Xingliao Talent" and the hundred talent level of "Hundred, Thousand and Ten Thousand Talent Project" in Liaoning Province. He is also a senior member of IEEE, a member of MMM Technical Committee of the International Federation of Automatic Control, a member of the "Random Neural Networks and Learning Systems" Working Group of the Neural Network Technical Committee of IEEE Computational Intelligence Society, a member of the Process Control Committee of the Chinese Association of Automation and other professional committees. He is mainly engaged in the research of industrial process modeling, control and operation optimization. He published more than 100 journal papers, published 2 academic monographs as the first author, and had more than 40 invention patents authorized. Besides, he has presided over more than 10 national and provincial ministerial projects including the major projects of the National Natural Science Foundation. Moreover, he won more than 10 awards such as the Second Prize of Natural Science of the Ministry of Education and the Excellent Doctor of the first Chinese Association of Automation.

Distinguished Lecture 6

Smart Data-Driven Soft Sensor Model for Quality Prediction of Multigrade Processes

Prof. Yi Liu
Zhejiang University of Technology, China

Thursday, Aug. 4, 2022
16:15-16:50
Grand Ballroom1(大宴会厅 1)

Abstract

Multigrade industrial processes have become increasingly important in satisfying the requirements of agile manufacturing and a diversified market. However, because of the unknown distribution discrepancy of multigrade process data, the development of reliable quality prediction models is still intractable, especially for the grades with limited quality measurements. In this work, several promising methods, including just-in-time probabilistic learning and transfer learning, have been proposed to develop smart soft sensors for the quality inferring of multigrade processes. A probabilistic analysis approach using the statistical property of steady-state grades is presented for description of the current state of a new sample. Additionally, an integrated probabilistic soft sensor modeling method which can select the suitable model for quality prediction of multigrade processes has been developed. By utilizing and transferring the useful information from different operating conditions to the existing soft sensor, the prediction domain is enlarged and the prediction accuracy is enhanced. Moreover, by reducing the data distribution discrepancy and enriching the information provided by the target domain, a domain adaptation-based supervised soft sensor outperforms conventional prediction models in terms of the range of prediction domains and prediction accuracy. Through simulated and industrial multigrade case studies, the feasibility of the developed methods was illustrated. The benefits of these soft sensors were discussed and highlighted.

Biography

Yi Liu received the Ph.D. degree in control theory and engineering from Zhejiang University, Hangzhou, China, in 2009. He was an Associate Professor with the Institute of Process Equipment and Control Engineering, Zhejiang University of Technology from 2011 to 2020. He was a Postdoctoral Researcher with the Department of Chemical Engineering, Chung-Yuan Christian University from February 2012 to June 2013. Since December 2020, He has been a Full Professor with Zhejiang University of Technology, Hangzhou, China. He has published over 50 research papers at IEEE Transactions and international journals in the field of process modeling and control. His research interests include data intelligence with applications to modeling, control, and optimization of industrial processes.

Distinguished Lecture 7

Data-Driven Iterative Learning Control

Prof. Ronghu Chi
Qingdao University of Science and Technology, China

Thursday, Aug. 4, 2022
16:50-17:25
Grand Ballroom1(大宴会厅 1)

Abstract

Artificial intelligence (AI) has experienced a great resurgence with a key characteristic of "Learning". In general case, learning refers to the action of system to adapt and change its behavior based on input/output (I/O) observations. Many control systems have this learning ability to respond to changes in its environment, including feedback control systems, adaptive control systems, or any type of artificial neural network equipped with a weight update algorithm. The primary goal of our work is centered on iterative learning control (ILC). The term "Iterative" indicates a kind of action that requires the dynamic process be repeatable, i.e., the dynamic system is deterministic and the tracking control is repeatable over a finite tracking interval. It is worth pointing out that the ILC was originally proposed for nonlinear uncertain systems directly using I/O data for the controller design without requiring the exact knowledge of the system model and thus is classified as data-driven control. However, many design and analysis methods of ILC systems still require some model information. For example, optimal ILC depends on the accuracy of the linear model of the system to guarantee the convergence. Therefore, our work mainly introduces some new design and analysis methods of data-driven ILC. First, the basic idea of data-driven ILC is introduced in this work, and then the latest advances of data-driven ILC are discussed with some significant problems of non-repetitive uncertainty, incomplete information, specified points tracking, higher-order learning algorithm, event-triggered mechanism, etc. Our work provides new insights into the learning control system design and analysis, so that many other learning methods can be incorporated in the control systems as a new branch of AI.

Biography

Ronghu Chi, Professor of the School of Automation and Electronic Engineering of Qingdao University of Science and Technology. He received the Ph.D. degree in systems engineering from Beijing Jiaotong University, Beijing China, in 2007. He was a Visiting Scholar with Nanyang Technological University, Singapore from 2011 to 2012 and a Visiting Professor with University of Alberta, Edmonton, AB, Canada from 2014 to 2015. He also serves as Deputy Secretary General of Data-driven Control, Learning and Optimization Professional Committee of China Automation Society, member of Process Control Professional Committee of China Automation Society, Director of Shandong Automation Society, Guest editor of International Journal of Automation and Computing. He was awarded the "Taishan scholarship" in 2016. He has presided over 3 general projects of NSFC, 5 provincial and ministerial level vertical projects and more than 10 horizontal projects and participated in 3 National Longitudinal topics. He has published more than 100 academic papers, including more than 70 refereed journal articles. He has successively won 2 provincial and ministerial scientific research awards and 4 municipal department level scientific research awards. More than 10 invention patents have been applied for and authorized. His current research interests include: data-driven control, iterative learning control, multi-agent systems, batch process control, etc.

Distinguished Lecture 8

Data-Driven Security Control against Network Attacks

Prof. Weiwei Che
Qingdao University, China

Thursday, Aug. 4, 2022
17:25-18:00
Grand Ballroom1(大宴会厅 1)

Abstract

In practical systems, the accurate models are usually difficult to obtain with the development of the industrial technology. Therefore, data-driven control methods have attracted more and more attention in the big data era. In addition, while providing convenience, the wireless network channels used to transmit a large amount of system data will be maliciously attacked. Thus, the security problem is very important for data-driven control methods. This report focuses on the data-driven security control problem against two types of denial-of-service attacks for a class of nonlinear systems. At the same time, two kinds of attack compensation mechanism are presented to alleviate the influence of network attacks, respectively.

Biography

Che Weiwei is currently a Professor and doctoral supervisor of the College of Automation, Qingdao University, Qingdao, China. She received the Ph.D. degree in navigation, guidance and control engineering from Northeastern University, Shenyang, China, in 2008. She was a Post-Doctoral Fellow with Nanyang Technological University, Singapore, from October 2008 to October 2009. From January 2015 to April 2015, she was a visiting scholar at the University of Hong Kong. From March 2017 to August 2017, she was concurrently employed in the department three of Information Science, National Natural Science Foundation of China. She was selected into Shandong Province Taishan Scholars Young Expert Program in 2018. She is currently the associate editor of International Journal of Fuzzy Systems. And she has presided over 3 national Natural Science Foundation of China (NSFC) projects, 1 joint key project sub-project of NSFC, 1 key project of Shandong Province, and more than 10 other provincial and ministerial projects. She has also published more than 50 SCI papers as the first and corresponding author.

Pre-Conference Workshop

Intelligent Railway Transportation System: Progress and Applications (智慧轨道交通系统：进展及应用)

Wednesday, Aug. 3, 2022
14:30-17:00
Emei Ballroom1(峨眉厅 1)

Workshop Abstract

智能化是未来轨道交通系统的发展方向，它将先进的信息技术、数据通讯传输技术、电子传感技术、控制技术及计算机技术等有效地集成运用于轨道交通系统，从而建立一种在大范围内、全方位发挥作用的，实时、准确、高效的综合运输管理系统。物联网、云计算、大数据、人工智能、自动控制、移动互联网等新一代技术的快速发展为智慧轨道交通提供了强大的技术支撑，为轨道交通建设、运输与管理，智能驾驶与智能运维等提供了新的业务模式，使轨道交通系统在区域、城市乃至更大的时空范围具备感知、互联、分析、预测、控制等能力，以充分保障轨道交通安全、发挥交通基础设施效能、提升交通系统运行效率和管理水平，为通畅的公众出行、高效的物资流动和可持续的经济发展服务。

本次研讨会的目的是报告智慧轨道交通系统的基础理论、先进控制与智能诊断技术及应用进展，包括高速列车追踪间隔定量控制与分析、异常振动发生机理分析、监测与控制、无人驾驶系统原理模型与应用实践、以及大秦、朔黄智慧重载铁路的技术创新与未来发展等。

Workshop Speakers

Speaker 1：江明 （北京全路通信信号研究设计院集团有限公司）
Title：列车追踪间隔定量分析研究
Abstract: 本报告主要介绍针对列车追踪间隔时间的定量分析研究。列车追踪间隔时间是线路通过能力的重要参数，报告以京沪高铁为例，全面梳理高速铁路列车追踪间隔时间的影响因素，深入分析各影响因素对追踪间隔时间的影响。按照不同专业的贡献率分析列车追踪间隔时间的构成，并采用仿真计算软件定量分析列车性能、线路条件、信号系统及其它因素对追踪间隔时间的影响。
Biography：江明，博士，正高级工程师，北京全路通信信号研究设计院集团有限公司首席专家、副总工程师，国务院政府特殊津贴专家。在高速铁路列控系统工程化、自主化、智能化和国际化等方面带领团队持续攻关，主持建成了高速铁路列控系统关键技术产业化平台，攻克了高速铁路网复杂工况下的列控系统全生命周期核心技术，实现了列控成套装备 100%国产化。创新成果在我国 4 万公里高铁网络得到广泛应用，成套设备通过欧盟互联互通认证并成功应用部署于欧洲匈塞铁路、印尼雅万高铁等海外铁路。

作为召集人主持 IEC 和 ISO 两个国际标准工作组，主编国际标准 2 项，参编国际标准 1 项，编制铁道行业标准 6 项，发表学术论文 30 余篇，获国际、中国授权发明专利 20 余项，曾荣获国家科技进步特等奖 1 项、铁道科技进步特等奖 2 项、中国交通运输协会科技进步奖特等奖 1 项，获其他省部级以上荣誉十余项。

Speaker 2：肖致明 （国能朔黄铁路发展有限责任公司）
Title：朔黄智慧重载铁路建设方案研究
Abstract：本报告系统阐述了朔黄智慧重载铁路建设方案，围绕国内外智慧铁路发展方向，从朔黄智慧重载铁路建设的迫切需求出发，着重介绍了朔黄在建设智慧重载铁路领域开展的工作、取得的成绩和积累的成果。最后，报告重点介绍了朔黄铁路目前在研科技项目情况，提出了下一步朔黄智慧重载铁路建设的重点方向。
Biography：肖致明，国能朔黄铁路发展有限责任公司副总经理，复旦大学软件工程硕士、北京交通大学运输工程硕士，国能朔黄铁路发展有限责任公司科学技术委员会副主任，国能朔黄铁路发展有限责任公司技术标准管理委员会副主任，国能朔黄铁路公司重载铁路基础设施智慧运维技术科研平台主任。

主要从事智慧重载货运铁路建设、运营等相关研究，拥有近 30 年铁路运营管理经验，牵头朔黄铁路开展重载铁路关键技术攻关、智能化设备研制和系统研发、标准技术体系建设等工作。全面负责《朔黄重载铁路移动闭塞扩大试验与工程化应用研究》、《朔黄重载铁路基础设施智能运维技术研究与应用》、《朔黄铁路黄骅港智能调车系统装备研制与示范应用》、《朔黄铁路 3 万吨级重载列车开行技术方案研究》、《基于移动闭塞的重载列车自动驾驶技术研究》等重大/前沿课题总体规划、组织实施和落地应用。

Speaker 3：路向阳 （中车株洲电力机车研究所有限公司）
Title：露天矿山运输无人驾驶系统原理模型研究与应用实践
Abstract：本报告主要针对露天矿山运输生产的特点，提出一种露天矿山运输卡车无人驾驶系统的原理模型。该模型由作业计划层、作业管理与监控层以及车辆作业层 3 层构成。通过将每一层的任务分解为若干功能模块，对每一模块的功能需求进行描述，阐述无人驾驶的车辆如何按照人的意愿自动运行的原理，勾画了矿山运输卡车无人驾驶系统的顶层设计轮廓。介绍了依照本模型设计的无人驾驶系统在矿山实际运输生产中 1 年多的编组作业运行应用实践。
Biography：路向阳，中国中车科学家、中车株洲电力机车研究所首席专家、株洲变流技术国家工程研究中心有限公司首席专家。长期从事自动化系统研究与产品开发，主持多项开创性或原创性科技攻关和产品开发、应用推广项目。作为项目负责人完成国家 863 计划“高速列车故障诊断与智能维护技术研究”、中国中车重大科技专项“城市轨道交通无人驾驶系统研究”、中国中车重大科技专项“矿用卡车无人驾驶系统研制”，作为副总设计师完成国家重大科技攻关项目“轨道交通安全保障系统”等重大项目。曾获国家科技进步二等奖 1 项，铁道学会特等奖 2 项，省部级科技进步二等奖 2 项；主持国际标准 1 项，策划或核心参与国际标准多项；主持编写国家标准 8 项、行业标准与团体标准 20 余项；发表核心期刊论文约 30 篇；出版专著《地铁列车自动驾驶系统原理》。

Speaker 4：凌亮 西南交通大学
Title：高速列车异常振动的发生机理与控制对策研究
Abstract：我国高铁路网规模最大、运营速度最高、运营环境极为复杂，高速列车经常长距离跨越不同地貌单元、不同地质条件、不同气候区域。在如此复杂多变的运营条件下，高速列车轮轨异常磨损、车辆横向晃动与异常抖动等问题逐渐凸显，如何保持长期服役过程中高速列车的高舒适性与高安全性，成为我国高速及更高速轨道交通发展中面临的关键问题。本报告主要介绍我国高速列车服役过程中典型横向晃动与垂向抖动等异常振动现象的基本特征、发生机理及可能的控制对策。
Biography：凌亮，工学博士，西南交通大学牵引动力国家重点实验室研究员、国家“万人计划”青年拔尖人才、全国铁路青年科技创新奖获得者、西南交通大学“扬华学者”。兼任行业核心期刊《International Journal of Rail Transportation》编委与副编辑，国际车辆系统动力学协会会员，国际轨道交通会议 ICRT2021 秘书，国际振动工程会议 ICVE'2021

车辆工程分会场联合发起人，国际车辆系统动力学会议 IAVSD2021 分会场主席。

凌亮博士长期从事列车与运行环境相互作用及服役安全控制领域的应用基础研究；在国内外权威学术期刊与会议上发表学术论文 100 余篇（第一/通讯作者 SCI 论文 30 篇），Google citations 1000 余次；主持国家自然科学基金项目、国家高层次人才特殊支持计划项目、国家重点研发计划项目子课题、中国铁路总公司系统性重大项目子课题、四川省应用基础项目等十余项科研课题。相关成果获国家科技进步二等奖，全国铁路青年科技创新奖，四川省高等教育教学成果一等奖，SCI 期刊《Acta Mechanica Sinica》年度最佳论文奖，詹天佑铁道科学技术专项奖，中国铁道学会优秀论文二等奖。

Speaker 5：危翔 （中国铁路太原局集团公司科学技术研究所）

Title：大秦重载铁路技术创新与发展

Abstract：大秦铁路是我国第一条重载货运铁路，于 1998 年开通运营，距今已有 34 年的历史。本报告将回顾我国重载铁路从落后到追赶、再到引领的跨越式发展历程，从车、机、工、电、辆多专业阐述大秦铁路的框架体系、技术创新和所取得的成果。最后从总体思路、研究构想和前沿技术等方面探讨我国重载铁路的未来发展。

Biography：危翔，男，教授级高工，中国铁路太原局集团公司科学技术研究所所长、重载铁路技术研究中心主任，曾任大秦铁路湖东电力机务段总工程师。作为我国重载大功率交流传动电力机车技术引进专家，长期从事重载铁路技术创新和现场应用工作，是大秦重载铁路 2 万吨及 3 万吨重载组合列车的开创实践者。带领技术团队先后获得省部级科技成果 12 项，取得 25 项国家专利，主导制定了中国铁路 15 个“铁路行车事故救援设备”标准。以破解重载技术现实安全问题为己任，开展了系列重载技术专项课题的研究，推动了大秦线重载技术升级和核心技术的自主创新，实现了中国货运重载技术的历史性突破。先后获得“茅以升铁道工程师奖”、“詹天佑铁道专项奖”、“铁道部火车头奖章”等荣誉。

2022 IEEE 11th Data Driven Control and Learning Systems Conference (DDCLS'22)

Technical Program
and
Book of Abstracts

Technical Program

Thursday, August 4, 2022

ThurA01 13:30–15:30 Room 1
Regular Session: Iterative Learning Control (I)

Chair: Dai, Xisheng — Guangxi Univ. of Sci. & Tech.,
Co-Chair: Tian, Senping — South China Univ. of Tech.

▶ ThurA01-1 13:30–13:50
State Consistency Tracking for A Class of Singular Multi-agent System Based on Iterative Learning Method
Liu, Hengheng — Sourth China Univ. of Tech.
Tian, Senping — South China Univ. of Tech.
Li, Xiangyang — South China Uni. of Tech
Luo, Rui — South China Univ. of Tech.

▶ ThurA01-2 13:50–14:10
Containment Control via Iterative Learning of Singular Multi-agent Systems with Multiple Leaders
Yang, Sizhe — South China Univ. of Tech.
Liu, Qian — Yantai Univ.
Tian, Senping — South China Univ. of Tech.
Li, Xiangyang — South China Uni. of Tech

▶ ThurA01-3 14:10–14:30
Group Consensus for First-order Multi-agent Systems by the Iterative Learning Control
Wang, Ruige — Xidian Univ.
Li, Jinsha — Xidian Univ.

▶ ThurA01-4 14:30–14:50
Weld Seam Extraction of Intersecting Pipelines Based on Point Cloud Entropy
Lu, Shuaibing — ShanDong Univ.
Shi, Xiaorui — SINOTRUK Jinan Power Co.,Ltd
Tian, Xincheng — Shandong Univ.
Liu, Yan — Shandong Univ.

▶ ThurA01-5 14:50–15:10
PD-type Distributed ILC Protocol of Consensus for Nonlinear Multi-agent System with Fuzzy Topology Structure
Li, Yueying — Gaungxi Univ. of Sci. & Tech.
Dai, Xisheng — Guangxi Univ. of Sci. & Tech.,

▶ ThurA01-6 15:10–15:30
Direct and Indirect Technique Routes of Convergence Analysis for Discrete-time Iterative Learning Control
Liu, Jian — Xidian Univ.
Jia, Changqing — Xidian Univ.

ThurA02 13:30–15:30 Room 3
Invited Session: Control and Learning in Human-Robot Interaction Systems

Organizer: Yang, Yong — Xihua Univ.
Organizer: Xing, Xueyan — Univ. of Sussex
Organizer: Li, Yanan — Univ. of Sussex
Chair: Yang, Yong — Xihua Univ.
Co-Chair: Xing, Xueyan — Univ. of Sussex

▶ ThurA02-1 13:30–13:50
Position Constraints Adaptive Iterative Learning Control of Exoskeleton for the Preliminary Stage of Rehabilitation
Jin, Shuping — XiHua Univ.
Yang, Yong — Xihua Univ.
Dong, Xiucheng — Xihua Univ.
Liu, Xia — Xihua Univ.
Xia, Peng — Xihua Univ.

▶ ThurA02-2 13:50–14:10
Control of Robotic Teleoperation System with Time Delay Based on Force Estimation
Sheng, Hao — Xihua Univ.
Liu, Xia — Xihua Univ.
Chen, Shini — Xihua Univ.
Jiang, Wenbo — Xihua Univ.
Guo, Yi — Xihua Univ.

▶ ThurA02-3 14:10–14:30
Robust ILC Approach for 2-D Linear Time-varying Continuous-discrete Systems
Wan, Kai — Huizhou Univ.
Wei, Xiao-Hui — School of Electronic Information & Electrical Engineering
Long, Dafeng — Huizhou Univ.
Xu, Qing-Yuan — Guangdong Polytechnic Normal Univ.

▶ ThurA02-4 14:30–14:50
Neural Networks Iterative Learning Impedance Control of Lower Limb Exoskeleton for the Later Stage of Rehabilitation
Xia, Peng — Xihua Univ.
Yang, Yong — Xihua Univ.
Jin, Shuping — XiHua Univ.
Liu, Xia — Xihua Univ.
Dong, Xiucheng — Xihua Univ.

▶ ThurA02-5 14:50–15:10
Iterative Learning Model Predictive Control for Lateral Control of Autonomous Vehicles
Chen, Yanfang — Sun Yat-sen Univ.
Li, Xuefang — National Univ. of Singapore

▶ ThurA02-6 15:10–15:30
Optimal Second-Order Integral Sliding Mode Control for Underactuated Robotic System
Hu, Pan — Xihua Univ.
Liu, Xia — Xihua Univ.
Jiang, Wenbo — Xihua Univ.
Guo, Yi — Xihua Univ.

ThurA03 13:30–15:30 Room 4
Regular Session: Data-driven Fault Diagnosis and Health Maintenance (I)

Chair: He, Yan-Lin — Beijing Univ. of Chemical Tech.
Co-Chair: Xiong, Zhihua — Tsinghua Univ.

▶ ThurA03-1 13:30–13:50
Operating Condition Identification of Complete Wind Turbine Using DBN and Improved DDPG-SOM
Wang, Zheng — Shanghai Jiao Tong Univ.
Chu, Xuening — Shanghai Jiao Tong Univ.

▶ ThurA03-2 13:50–14:10
Multiple Recurrent Neural Networks Based Fault Diagnosis Model for Multi-mode Process
Wan, Chuan — Tsinghua Univ.
Zhang, Tongshuai — Tsinghua Univ.
Yang, Xiaojun — Tsinghua Univ.
Xiong, Zhihua — Tsinghua Univ.

▶ ThurA03-3 14:10–14:30
Knowledge Graph for Fault Diagnosis of Mechanical System
Chen, Hao — State Key Laboratory of Internet of Things for Smart City & Department of Electromechanical Engineering, Univ. of Macau
Wang, Xian-Bo — State Key Laboratory of Internet of Things for Smart City & Department of Electromechanical Engineering, Univ. of Macau
Yang, Zhi-Xin — Univ. of Macau

▶ ThurA03-4 14:30–14:50
Novel ARMF Integrated with Improved LSDA and Its Application in Fault Diagnosis
Zhu, Qunxiong — Beijing Univ. of Chemical Tech.
Zhang, Ning — Beijing Univ. of Chemical Tech.
He, Yan-Lin — Beijing Univ. of Chemical Tech.
Xu, Yuan — BEIJING Univ. OF CHEMICAL Tech.

▶ ThurA03-5 14:50–15:10
Control Performance Monitoring of RtR Controllers Based on Improved KL Divergence in Semiconductor Manufacturing Processes
Ling, Dan — Zhengzhou Univ. of Light Industry

Li, Chaosong Zhengzhou Univ. of Light Industry
Lei, Ting Zhengzhou Univ. of Light Industry
Wang, Yan Zhengzhou Univ. of Light Industry
Guo, Danlei Zhengzhou Univ. of Light Industry

▶ ThurA03-6 15:10–15:30
Bearing Fault Diagnosis Based on Multiple Feature Transfer Learning Network
Qiao, Huanzhang Shandong Univ.
Liu, Lida Shandong Raone Tech. Co., LTD
Tian, Xincheng Shandong Univ.
Liu, Yan Shandong Univ.

ThurA04 13:30–15:30 Room 5
Regular Session: Statistical Learning and Machine Learning in Automation Field (I)
Chair: Wang, Youqing -
Co-Chair: Tian, Xincheng Shandong Univ.

▶ ThurA04-1 13:30–13:50
Vehicle Tracking Method Based on Attention-YOLOv5 and Optimized DeepSort Models
Li, Zhuang Shandong Univ.
Tian, Xincheng Shandong Univ.
Liu, Yan Shandong Univ.
Shi, Xiaorui SINOTRUK Jinan Power Co.,Ltd

▶ ThurA04-2 13:50–14:10
An Accurate Feature Extraction Cluster Algorithm for Damage Detection Based on Thermography
Zhang, Bo Univ. of Electronic Sci. & Tech.
Yin, Chun Univ. of Electronic Sci. & Tech. of China
Huang, Xuegang China Aerodynamics Research & Development

▶ ThurA04-3 14:10–14:30
Ballast Resistance Estimation Method Based on One Dimensional Convolutional Neural Network
Xie, Yuxin Beijing JiaoTong Univ.
Yang, Shiwu Beijing Jiaotong Univ.
Liu, Chang Beijing Jiaotong Univ.
Wang, Conghui Beijing Jiaotong Univ.

▶ ThurA04-4 14:30–14:50
EEG Motor Imagery Decoding Based on Common Spatial Pattern and Ensemble Learning at the Source Space
Huang, Jiazhang Chongqing Univ. of Posts & Telecommunications
Liu, Ke Chongqing Unversity of Posts & Telecommunications
Deng, Xin Chongqing Univ. of Posts & Telecommunications

▶ ThurA04-5 14:50–15:10
Fault Diagnosis of Rolling Bearing Based on Improved Convolutional Neural Network
Lin, Zichen Huzhou Univ.
Wang, Peiliang Huzhou Univ.
Chen, Yangde Huzhou Univ.
Sun, Chenhao Huzhou Univ.

▶ ThurA04-6 15:10–15:30
Semi-Distributed Intermediate Observer for Heterogeneous Multi-Agent Systems with Homologous Fault
Sheng, Jie Shandong Univ. of Sci. & Tech.
Wang, Youqing -

ThurA05 13:30–15:30 Room 6
Regular Session: Model-free Adaptive Control
Chair: Yao, Wen-Long Qingdao Univ. of Sci. & Tech.
Co-Chair: Cao, Rongmin Beijing Information Sci. & Tech. of Univ.

▶ ThurA05-1 13:30–13:50
Maximum Power Point Tracking of Merchant Marine Photovoltaic System Based on MFALC
Zhuang, Yongbo Qingdao Port International Co., Ltd
Pei, Chunbo Qingdao Univ. of Sci. & Tech.
Yao, Wen-Long Qingdao Univ. of Sci. & Tech.
Chi, Ronghu Qingdao Univ. of Sci. & Tech.
Wen, Hongjie Qingdao Port International Co., Ltd
Guo, Yiyun Ocean Univ. of China

▶ ThurA05-2 13:50–14:10
Multiple Input Multiple Output Model-free Adaptive Iterative Learning Control of Two-dimensional Linear Motor Based on Neural Network
Zheng, Xinxin Beijing Univ. of Information Tech.
Cao, Rongmin Beijing Information Sci. & Tech. of Univ.
Hou, Zhongsheng Beijing Jiaotong Univ.

▶ ThurA05-3 14:10–14:30
Inverse-Free Tracking Control of Continuum Robots with Unknown Models Based on Gradient Neural Networks
Yu, Peng Sun Yat-sen Univ.
Tan, Ning Sun Yat-sen Univ.
Zhang, Mao SUN YAT-SEN Univ.
Ni, Fenglei Harbin Inst. of Tech.

▶ ThurA05-4 14:30–14:50
An Improved Feedback-feedforward Model-free Adaptive Iterative Learning Control with High-order Estimation
Ji, Honghai North China Univ. of Tech.
You, Yue North China Univ. of Tech.
Liu, Shida Beijing Jiaotong Univ.
Fan, Lingling Beijing Information Sci. & Tech. Univ.
Hou, Zhongsheng Beijing Jiaotong Univ.

▶ ThurA05-5 14:50–15:10
Event-Triggered Model-Free Adaptive Predictive Control for Nonlinear NCSs Subject to Data Dropout Compensation and Application in PMSM Control System
Wang, Yu Qingdao Univ.
Hou, Zhongsheng Beijing Jiaotong Univ.

▶ ThurA05-6 15:10–15:30
Adaptive Nonlinear Variable Gain PID Controller for 3D Obstacle Avoidance of Delivery Drone
Zhang, Yanhui Zhejiang Univ.
Chen, Weifang Zhejiang Univ.

ThurA06 13:30–15:35 Room 7
Award Session: Best Paper
Chair: SUN, Mingxuan Zhejiang Univ. of Tech.

▶ ThurA06-1 13:30–13:55
Moving-target-enclosing Control for Multiple Nonholonomic Mobile Agents with Bearing Measurements
Ju, Shuang Beijing Univ. of Chemical Tech.
Wang, Jing North China Univ. of Tech., China
Dou, Liya Beijing Univ. of Chemical Tech.

▶ ThurA06-2 13:55–14:20
Fast Depth Estimation of Object via Neural Network Perspective Projection
Yu, Han Chinese Acad. of Sci.
Chen, Yaran Chinese Acad. of Sci.
Li, Haoran Univ. of Chinese Acad. of Sci.
Ma, Mingjun Chinese Acad. of Sci.
Zhao, Dong-Bin Inst. of Automation

▶ ThurA06-3 14:20–14:45
Extended Iterative Learning Control for Inconsistent Tracking Problems with Random Dropouts
Zhang, Zeyi Renmin Univ. of China
Jiang, Hao Renmin Univ. of China
Shen, Dong Renmin Univ. of China

▶ ThurA06-4 14:45–15:10
Finite-iteration Adaptive ILC for Automatic Operation of High-speed Trains
Yu, Qiongxia Henan Polytechnic Univ.
Hou, Yiteng Henan Polytechnic Univ.
Tian, Fengchen Henan Polytechnic Univ.
Bu, Xuhui Henan Polytechnic Univ.

▶ ThurA06-5 15:10–15:35
Multi-Player Robust Control of Stackelberg Games via Adaptive Dynamic Programming
Zhang, Yongwei School of Automation
Zhang, Shunchao Guangdong Univ. of Tech.
Zhao, Bo Beijing Normal Univ.
Liu, Derong CASIA

ThurB01 15:40–17:40 Room 1
Regular Session: Data Driven Control (I)
Chair: You, Keyou Tsinghua Univ.
Co-Chair: Zheng, Dongdong Beijing Inst. of Tech.

▶ ThurB01-1 15:40–16:00
Controller Design of Linear Systems via Policy Optimization Methods
Zhao, Feiran Tsinghua Univ.

You, Keyou Tsinghua Univ.

▶ ThurB01-2 16:00–16:20
How Much Data is Sufficient for Linear System Analysis without Explicit Model?
Kang, Shubo Tsinghua Univ.
You, Keyou Tsinghua Univ.

▶ ThurB01-3 16:20–16:40
Unknown System Dynamics Estimator for Motion Control of Robotic Manipulator with Flexible Joints
Li, Yantian Kunming Univ. of Sci. & Tech.
Huang, Yingbo Kunming Univ. of Sci. & Tech.
Na, Jing Kunming Univ. of Sci. & Tech.
Wang, Xian Kunming Univ. of Sci. & Tech.
Gao, Guanbin Kunming Univ. of Sci. & Tech.

▶ ThurB01-4 16:40–17:00
USDE-Based Approximation-Free Control for Robot System with Prescribed Performance
Zhang, Chao Beijing Inst. of Tech.
Ren, Xuemei Beijing Inst. of Tech.
Zheng, Dongdong Beijing Inst. of Tech.

▶ ThurB01-5 17:00–17:20
Data-driven Control of Event-triggered Linear Systems
Wang, Xin Beijing Inst. of Tech.
Sun, Jian Beijing Inst. of Tech.
Wang, Gang Beijing Inst. of Tech.

▶ ThurB01-6 17:20–17:40
Data-driven ESO-based LOS Guidance Law for Path Following of Unmanned Surface Vehicles with Sideslip Compensation
Zhang, Wenjun Dalian Maritime Univ.
Wang, Fuqiang Dalian Maritime Univ.
Zhai, Lirong Liaoning Univ.

ThurB02 15:40–17:40 Room 3
Regular Session: Data-driven Control for Practical Complex Processes
Chair: Bu, Xuhui Henan Polytechnic Univ.
Co-Chair: Mi, Bo Chongqing Jiaotong Univ.

▶ ThurB02-1 15:40–16:00
Tracking Control of Two Virtually Coupled Trains via Prescribed Performance Control Method
Jia, Yuqi Southwest Jiaotong Univ.
Huang, Deqing Southwest Jiaotong Univ.
Li, Xuefang National Univ. of Singapore

▶ ThurB02-2 16:00–16:20
Model-free Adaptive Sliding Mode Control for Interconnected Power Systems under DoS Attacks
Chen, Zongyao Henan Polytechnic Univ.
Bu, Xuhui Henan Polytechnic Univ.
Guo, Jinli Henan Polytechnic Univ.

▶ ThurB02-3 16:20–16:40
Performance Analysis of Optimal Relay Selection for Urban Vehicles Based on Max-min Strategy
Yi, Junjie North China Univ. of Tech.
Liu, Lei North China Univ. of Tech.

▶ ThurB02-4 16:40–17:00
A New IBE Scheme Based on Conjugate Search Problem
Deng, Zhaoyang Chongqing Jiaotong Univ.
Mi, Bo Chongqing Jiaotong Univ.
Huang, Darong Chongqing Jiaotong Univ.
Hao, Lingyi Chongqing Jiaotong Univ.

▶ ThurB02-5 17:00–17:20
Research on Competition-reciprocity Network of State Owned Commercial Banks in Wuhan and Its Statistics Analysis
Liu, Jie Wuhan Textile Univ.

▶ ThurB02-6 17:20–17:40
Distance-based Formation Control of Holonomic Mobile Robot Multi-agent System in Finite Time
Lei, Qiao Lanzhou Jiaotong Univ.
Li, Zonggang Lanzhou Jiaotong Univ.

ThurB03 15:40–17:40 Room 4
Invited Session: ADRC: Design, Theory and Application
Organizer: Yang, Zhijun Guangdong Univ. of Tech.
Organizer: Chen, Sen Shaanxi Normal Univ.
Organizer: Zhao, Zhiliang Shaanxi Normal Univ.
Chair: Yang, Zhijun Guangdong Univ. of Tech.
Co-Chair: Qi, Guoyuan Tiangong Univ.

▶ ThurB03-1 15:40–16:00
Fixed-time Switching Sliding Mode Control for Second-order Nonlinear Systems
Wei, Xinyi Nankai Univ.
Wang, Fuyong Nankai Univ.
Liu, Zhongxin College of Artificial Intelligent, NanKai Univ.
Chen, Zengqiang Nankai Univ.

▶ ThurB03-2 16:00–16:20
Cascade Sliding Mode Control of Four-sided Clamped Plate Based on Extended State Observer
Gu, Renjing Yangzhou Univ.
Li, Shengquan Yangzhou Univ.
Zhang, Luyao Yangzhou Univ.
Zhang, Jie Yangzhou Univ.
Li, Juan Southeast Univ.

▶ ThurB03-3 16:20–16:40
A Composite Linear Active Disturbance Rejection Fault Tolerant Controller for A PMSM System in Unbalanced Load Fault: Design and Hardware Implementation
Luo, Lin Yangzhou Univ.
Sun, Song Yangzhou Univ.
Li, Juan Southeast Univ.
Li, Shengquan Yangzhou Univ.

▶ ThurB03-4 16:40–17:00
Event-triggering-based Leader-following Consensus of Second-order Multi-agent Systems with Mismatched Disturbances
Jiayi, Gong Nankai Univ.
Wang, Fuyong Nankai Univ.
Liu, Zhongxin College of Artificial Intelligent, NanKai Univ.
Chen, Zengqiang Nankai Univ.

▶ ThurB03-5 17:00–17:20
Compensation Function Observer-based Backstepping Control and Application in Quadrotor UAV
Deng, Jiahao Tiangong Univ.
Qi, Guoyuan Tiangong Univ.

▶ ThurB03-6 17:20–17:40
CFO-based Model Compensation Control and Its Application in QUAV Trajectory Tracking
Li, Xia Tiangong Univ.
Qi, Guoyuan Tiangong Univ.

ThurB04 15:40–17:40 Room 5
Invited Session: Explainable Fault Diagnosis and Performance Optimization
Organizer: Chen, Hongtian Univ. of Alberta
Organizer: Huang, Darong Chongqing Jiao-tong Univ.
Organizer: Shang, Chao Tsinghua Univ.
Chair: Chen, Hongtian Univ. of Alberta
Co-Chair: Shang, Chao Tsinghua Univ.

▶ ThurB04-1 15:40–16:00
Convolutional Neural Networks-aided Canonical Correlation Analysis to Fault Classification
Yang, Xinyu Inst. of Computer Sci. & Engineering, Changchun Univ. of Tech.
Zhai, Shuang Changchun Univ. of Tech.
Cheng, Chao School of Computer Sci. & Engineering, Changchun Univ. of Tech.
Chen, Hongtian Univ. of Alberta

▶ ThurB04-2 16:00–16:20
A Segmental Autoencoder-based Fault Detection for Nonlinear Dynamic Systems: An Interpretable Learning Framework
Chen, Hongtian Univ. of Alberta
Pan, Zhuofu Central South Univ.
Dogru, Oguzhan Univ. of Alberta
Wang, Yalin Central South Univ.
Huang, Biao Univ. of Alberta

▶ ThurB04-3 16:20–16:40

Consensus Control of Heterogeneous Time-varying Multi-agent Systems under Multiple Sensors
Xiang, Guoliang — SUZHOU Univ. OF Sci. & Tech.
You, Renyang — Suzhou Univ. of Sci. & Tech.
Guo, Shenghui — Suzhou Univ. of Sci. & Tech.

▶ ThurB04-4 16:40–17:00
Process Monitoring of Operational Cost for Wastewater Treatment Processes Using Variants of ARMA Models Based Soft-sensors
Lu, Yu — South China Univ. of Tech.
Liu, Yiqi — South China Univ. of Tech.
Li, Dong — South China Univ. of Tech.

▶ ThurB04-5 17:00–17:20
Enhanced Discriminant Analysis Based Fault Diagnosis Scheme for Marine Diesel Engines
Zhong, Kai — Anhui Univerisity
Jiayi, Wang — Anhui Univ.
Pan, Donghui — Anhui Univ.

▶ ThurB04-6 17:20–17:40
基于慢变化准则的工业大数据解析及故障诊断方法
Shang, Chao — Tsinghua Univ.

ThurB05 15:40–17:40 Room 6
Regular Session: Data-driven Modeling, Optimization and Scheduling (I)
Chair: Liu, Qie — Chongqing Univ.
Co-Chair: Xu, Bao-Chang — China Univ. of Petroleum ,Beijing

▶ ThurB05-1 15:40–16:00
A Robust Two-step Iterative Approach for the Identification of Hammerstein Box-Jenkins Systems
Xu, Bao-Chang — China Univ. of Petroleum ,Beijing
Zhu, Shiyuan — China Univ. of Petroleum
Wang, Yaxin — China Univ. of Petroleum-Beijing
Yuan, Likun — China Univ. of Petroleum, Beijing
Wang, Zhu — China Univ. of Petroleum (Beijing)

▶ ThurB05-2 16:00–16:20
Interval Type-2 Dynamic Fuzzy Neural Network with Tensor Inverse
Hu, Jiale — Inner Mongolia Univ.
Zhao, Guoliang — Heilongjiang Univ. of Sci. & Tech.
Huang, Sharina — Heilongjiang Univ. of Sci. & Tech.
Dai, Huhe — Inner Mongolia Univ.

▶ ThurB05-3 16:20–16:40
Non-iterative Estimation Algorithm for Time-delay Hammerstein State Space System
Sun, Xueqi — Jiangsu Univ. of Tech.
Li, Feng — Jiangsu Univ. of Tech.
Cao, Qingfeng — Yangzhou Univ.

▶ ThurB05-4 16:40–17:00
A 2D UAV Path Planning Method Based on Reinforcement Learning in the Presence of Dense Obstacles and Kinematic Constraints
Tang, Xinming — Chongqing Univ.
Chai, Yi — Chongqing Univ.
Liu, Qie — Chongqing Univ.

▶ ThurB05-5 17:00–17:20
Carrier Aircraft Scheduling Optimization Based on A Algorithm and Genetic Algorithm*
Li, Mingwei — Southwest Jiaotong Univ.
Qin, Na — Southwest Jiaotong Univ.
Zhu, Tao — Southwest Jiaotong Univ.

▶ ThurB05-6 17:20–17:40
A Train Cooperative Operation Optimization Method Considering Passenger Comfort Based on Reinforcement Learning
Wang, Xingguo — Inst. of Sys. Sci. & Tech.
Wu, Yue — Southwest Jiaotong Univ.
Huang, Deqing — Southwest Jiaotong Univ.
Zhu, Lei — Southwest Jiaotong Univ.
Lu, Zheng — Southwest Jiaotong Univ.
He, Yan — Southwest Jiaotong Univ.

Friday, August 5, 2022

FriA01 08:00–10:00 Room 1
Regular Session: Iterative Learning Control (II)

Chair: Shen, Dong — Renmin Univ. of China
Co-Chair: Li, Xiao-Dong — Sun Yat-sen Univ.

▶ FriA01-1 08:00–08:20
Linear Active Disturbance Rejection Magnetic Levitation System Based on Cuckoo Search
Wei, Libing — Jiangxi Univ. of Sci. & Tech.
Fan, Kuangang — Jiangxi Univ. of Sci. & Tech.
Zhou, Xiaohua — Jilin Univ.
Hu, Lingfeng — School of Electrical Engineering & Automation
Tan, Wengang — Shandong Urban Construction Design Inst.

▶ FriA01-2 08:20–08:40
Iterative Learning Control for Multi-Agent Systems over Unknown Fading Networks
He, Xun — Renmin Univ. of China
Jiang, Hao — Renmin Univ. of China
Shen, Dong — Renmin Univ. of China

▶ FriA01-3 08:40–09:00
Discrete-Time Integral Terminal Sliding Mode Based Repetitive Control for Periodic Motion Tracking
Feng, Zhao — Univ. of Macau
Ling, Jie — Nanjing Univ. of Aeronautics & Astronautics
Shen, Yayi — Nanjing Univ. of Aeronautics & Astronautics

▶ FriA01-4 09:00–09:20
Discrete Active Disturbance Rejection Iterative Learning Control Based on Dynamic Linearization
Ai, Wei — South China Univ. of Tech.
Li, Xinling — South China Univ. of Tech.
Li, Xiangyang — South China Uni. of Tech

▶ FriA01-5 09:20–09:40
Stability of Linear Hyperbolic Distributed Parameter Systems Based on Event-triggered Control
Ni, Min — Guangxi Univ. of Sci. & Tech.
Dai, Xisheng — Guangxi Univ. of Sci. & Tech.,
Zhang, Jiaming — Guangxi Univ. of Sci. & Tech.
Wu, Qiqi — Guangxi Univ. of Sci. & Tech.
Zuo, Huang — Guangxi Univ. of Sci. & Tech.

▶ FriA01-6 09:40–10:00
Data-Driven Norm-Optimal-Gain-Adaptive Iterative Learning Control for LDTI Systems
Liu, Chuyang — Xi'an Jiaotong Univ.
Ruan, Xiaoe — Xi'an Jiaotong Univ.

FriA02 08:00–10:00 Room 3
Invited Session: Repetitive Control and its Recent Advance in Practice

Organizer: Ye, Yongqiang — Nanjing Univ. of Aeronautics & Astronautics
Organizer: Quan, Quan — Beihang Univ.
Chair: Ye, Yongqiang — Nanjing Univ. of Aeronautics & Astronautics
Co-Chair: Quan, Quan — Beihang Univ.

▶ FriA02-1 08:00–08:20
Error-driven Tracking Control Design with Preset-Input LMS Adaptive Filter
Liu, Qingquan — Harbin Inst. of Tech.
Huo, Xin — Harbin Inst. of Tech.
Liu, Kang-Zhi — Chiba Univ.
Zhao, Hui — Harbin Inst. of Tech.
Wu, Aijing — Harbin Inst. of Tech.

▶ FriA02-2 08:20–08:40
Adaptive Repetitive Control for A Class of Uncertain Nonlinear Systems Based on Additive-state-decomposition and Dynamic Surface Technique
Sun, Yongbo — Hunan Univ. of Sci. & Tech.
Zhou, Lan — Hunan Univ. of Sci. & Tech.
Jia, Fengyi — Hunan Univ. of Sci. & Tech.
Gao, Dongxu — Hunan Univ. of Sci. & Tech.

▶ FriA02-3 08:40–09:00
Analysis and Design of Repetitive Control Composite Controller for Grid-tied Inverter
Chen, Sainan — Nanjing Univ. of Aeronautics & Astronautics
Ye, Yongqiang — Nanjing Univ. of Aeronautics & Astronautics

▶ FriA02-4 09:00–09:20
Sampled-data Repetitive Control for A Class of Non-minimum Phase Nonlinear Systems Subject to Period Variation
Quan, Quan — Beihang Univ.

▶ FriA02-5 09:20–09:40
Frequency Adaptive Feedforward Odd-Harmonic Repetitive Control for A Grid-Tied Inverter
Zhang, Gong — Zhongyuan Univ. of Tech.
Zhao, Qiangsong — Zhongyuan Univ. of Tech.

▶ FriA02-6 09:40–10:00
Unknown System Dynamics Estimator-Based Fast Nonsingular Terminal Sliding Mode Control for An Omnidirectional Mobile Robot
Zhang, Fangfang — Kunming Univ. of Sci. & Tech.
Na, Jing — Kunming Univ. of Sci. & Tech.
Yang, Chunxi — Kunming Univ. of Sci. & Tech.
Huang, Yingbo — Kunming Univ. of Sci. & Tech.

FriA03 08:00–10:00 Room 4
Regular Session: Data-driven Modeling, Optimization and Scheduling(II)

Chair: Liu, Han — Xi'an Univ. of Tech.
Co-Chair: Qin, Na — Southwest Jiaotong Univ.

▶ FriA03-1 08:00–08:20
*Multiple Carrier UAV Path Planning Based on Hybrid A**
Zhu, Tao — Southwest Jiaotong Univ.
Qin, Na — Southwest Jiaotong Univ.
Huang, Deqing — Southwest Jiaotong Univ.
Li, Mingwei — Southwest Jiaotong Univ.
Mao, Yongjie — Southwest Jiao Tong Univ.
Chen, Dewang — Southwest Jiaotong Univ.

▶ FriA03-2 08:20–08:40
A Novel Soft Sensor Model Based on Stacking Ensemble Learning Framework
He, Zhao — Xi'an Univ. of Tech.
Liu, Han — Xi'an Univ. of Tech.

▶ FriA03-3 08:40–09:00
Wind Power Prediction Based on the Stacking Model of XGBoost and Random Forest
Liu, Wang-Jie — Shanghai Univ.
Jia, Li — Shanghai Univ.

▶ FriA03-4 09:00–09:20
Research on Optimal Resource Allocation of UAV Customized Cloud Platform Based on Bi-level Programming
Wu, Yanxia — Sys. Engineering Research Inst., China State Shipbuilding Corporation Limited
Yang, Li — Sys. Engineering Research Inst.
Wang, Hao — Sys. Engineering Research Inst., China State Shipbuilding Corporation Limited
Fan, Yao — Sys. ENGINEERING RESEARCH Inst.
Qiu, Xingye — Sys. Engineering Research Inst.
Zhang, Youshan — Sys. Engineering Research Inst.,China State Shipbuilding Corporation Limited
Li, Ling — Sys. Engineering Research Inst., China State Shipbuilding Corporation Limited
Liu, Geng — Sys. Engineering Research Inst.

▶ FriA03-5 09:20–09:40
Research on the Structure Model of Knowledge Manufacturing and Service System of Smart Library Based on Super-network
Wei, Qiongqiong — Qingdao Univ. of Sci. & Tech.
Zhu, Yanshuo — Qingdao Univ. of Sci. & Tech.

▶ FriA03-6 09:40–10:00
An Optimization Method for Multi-Train Coordinated Energy-Saving Operation in Metro System
Huang, Deqing — Southwest Jiaotong Univ.
Cai, Hanlin — School of Tangshan Graduate

FriA04 08:00–10:00 Room 5
Regular Session: Applications of Data-driven Methods to Industrial Processes

Chair: Han, Yongming — Beijing Univ. of Chemical Tech.
Co-Chair: Ji, Honghai — North China Univ. of Tech.

▶ FriA04-1 08:00–08:20
Pipeline Network Calculation Based on Improved IN-IGA Algorithm
Cong, Di — Beijing Univ. of Chemical Tech.
Li, Jun — Beijing Univ. of Chemical Tech.
Han, Yongming — Beijing Univ. of Chemical Tech.
Wei, Chunyang — Beijing Univ. of Chemical Tech.
Geng, Zhiqiang — Beijing Univ. of Chemical Tech.

▶ FriA04-2 08:20–08:40
Active Learning-Based Complex Pipelines Weld Defect Detection with Lightweight Neural Network
Zuo, Fengyuan — Northeastern Univ.
Liu, Jinhai — Univ. of Northeastern
Wang, Lei — Northeastern Univ.
Qu, Fuming — Univ. of Northeastern
Fu, Mingrui — Univ. of Northeastern

▶ FriA04-3 08:40–09:00
Secondary Reheat Steam Temperature Prediction Based on Hybrid Deep Learning
Gao, Yu Qing — Southeast Univ.
Xue, Yali — Tsinghua Univ.
Sun, Li — Southeast Univ., Http://power.seu.edu.cn/sl/list.htm

▶ FriA04-4 09:00–09:20
A Deep-Convolution-Generative-Adversarial-Networks-based Missing Data Filling Method for Blast Furnace Gas System in Steel Industry
Yang, Canguang — Dalian Univ. of Tech.
Jin, Feng — Dalian Univ. of Tech.
Zhao, Jun — Dalian Univ. of Tech.
Wang, Wei — Dalian Univ. of Tech.

▶ FriA04-5 09:20–09:40
An Automatic Train Operation Strategy Based on Prescribed Performance Control
Li, Zikang — Southwest Jiaotong Univ.
Wu, Yanzhi — Southwest Jiaotong Univ.
Huang, Deqing — Southwest Jiaotong Univ.
Cai, Hanlin — School of Tangshan Graduate

▶ FriA04-6 09:40–10:00
Data-driven Model Predictive Control for Heterogeneous Vehicular Platoon with Subspace Identification
Wu, Yanhong — Tianjin Univ.
Zuo, Zhiqiang — Tianjin Univ.
Wang, Yijing — Tianjin Univ.

FriA05 08:00–10:00 Room 6
Invited Session: Advanced Control for Fuzzy and Time Delay Nonlinear Systems
Chair: Han, Weixin — Northwestern Polytechnical Univ.
Co-Chair: Wu, Yue — Southwest Jiaotong Univ.

▶ FriA05-1 08:00–08:20
Data-Based Adaptive Integral Sliding-Mode Secure Control for Cyber-Physical Power Systems with Disturbance under Bias Injection Attacks
Han, Xinyu — Northeast Electric Power Univ.
Huang, Xin — Northeast Electric Power Univ.

▶ FriA05-2 08:20–08:40
H^∞ control for uncertain T-S fuzzy systems
Wu, Yue — Southwest Jiaotong Univ.
Cai, Liangcheng — Southwest JiaoTong Univ.

▶ FriA05-3 08:40–09:00
Energy Router Optimization Strategy Based on LSTM Algorithm for Real-Time Congestion Prediction
Chen, Xu — Anhui Polytechnic Univ.
Zhang, Yan — Anhui Polytechnic Univ.

▶ FriA05-4 09:00–09:20
Stabilization Control of Underactuated Cart-double-pendulum System
Fan, Lu — Linyi Univ.
Zhang, Ancai — Linyi Univ.
Li, Ning — Linyi Univ.
Zhang, Xinghui — Linyi Univ.
Pang, Guochen — Linyi Univ.

▶ FriA05-5 09:20–09:40
Model-free Adaptive Attitude Control for Combined Spacecraft with Input Saturation and Prescribed Performance
Huang, Xiuwei — Ji Hua Laboratory
Dong, Zhiyan — Fudan Univ.
Zhang, Feng — China Acad. of Launch Vehicle Tech.
Zhang, Lihua — Fudan Univ.

▶ FriA05-6 09:40–10:00
A Non-central Multi-Agent Routing Protocol of Self-organized Wireless Network for Missile Swarm Communication
Lu, Xiaodong — Northwestern Polytechnical Univ.
Wang, Chenzhao — Northwestern Polytechnical Univ.
Huo, Junxin — Northwestern Polytechnical Univ.
Wang, Wei — Northwestern Polytechnical Univ.

FriA06 08:00–10:00 Room 7
Regular Session: ILC and Adaptive Control
Chair: Li, Xuefang — National Univ. of Singapore
Co-Chair: Lu, Wenzhou — Jiangnan Univ.

▶ FriA06-1 08:00–08:20
The Second-Order 6k±1-Order Repetitive Control for Three-Phase Grid-connected Inverter
Lu, Wenzhou — Jiangnan Univ.
Hu, Licong — Jiangnan Univ.
Wang, Wei — Jilin Electric Power Co., Ltd., State Grid Corporation of China
Zhou, Keliang — Wuhan Univ. of Tech.
Lang, Yongbo — Jilin Electric Power Co., Ltd., State Grid Corporation of China
Zhang, Zhongbao — Jilin Electric Power Co., Ltd., State Grid Corporation of China

▶ FriA06-2 08:20–08:40
Autonomous Drone Racing: Spatial Iterative Learning Control Within A Virtual Tube
Lv, Shuli — Beihang Univ.
Yan, Gao — Beihang Univ.
Che, Jiaxing — Beihang Univ.
Quan, Quan — Beihang Univ.

▶ FriA06-3 08:40–09:00
Adaptive Path Tracking Control for Autonomous Vehicles with Input Constraints and Actuator Faults
Li, Hongbo — Sun Yat-sen Univ.
Li, Xuefang — National Univ. of Singapore

▶ FriA06-4 09:00–09:20
Discrete Fourier Transform Based Frequency Characteristics of PD-type Iterative Learning Control
Li, Xiaohui — Northwest A & F Univ.
Ruan, Xiaoe — Xi'an Jiaotong Univ.

▶ FriA06-5 09:20–09:40
Adaptive Iterative Learning Control for High-Speed Train Based on Multi-Agent Framework
Huang, Deqing — Southwest Jiaotong Univ.
Chen, Yong — Zhejiang Univ.

▶ FriA06-6 09:40–10:00
On Finite-Iteration Convergence of Iterative Learning Control
Liu, Zhiqing — Qingdao Univ. of Sci. & Tech.
Chi, Ronghu — Qingdao Univ. of Sci. & Tech.
Liu, Yang — Guangdong Univ. of Tech.

Poster Session FriA07
Aug. 5, 8:00–10:00
Emei Ballroom
Chair: Xiong, Wenjun — Southwestern Univ. of Finance & Economics
Co-Chair: Li, Sheng — Zhejiang Univ. of Tech.

▷ FriA07-01
An Approach to the Extraction of Intersecting Pipes Weld Seam Based on 3D Point Cloud
Yang, Shuai — Shandong Univ.
Shi, Xiaorui — SINOTRUK Jinan Power Co.,Ltd
Tian, Xincheng — Shandong Univ.
Liu, Yan — Shandong Univ.

▷ FriA07-02
The Design of Robust Adaptive Controller Based on JITL Method for Nonlinear Process
Zhou, Liuming — Shanghai Univ.
Li, Feng — Jiangsu Univ. of Tech.

▷ FriA07-03
Data-Based Control Design for Learning Systems
Wu, Yuxin — Beihang Univ.
Meng, Deyuan — Beihang Univ. (BUAA)

▷ FriA07-04
Trajectory Tracking of Bus Based on Feedback-feedforward Model Free Adaptive Control
Ren, Ye — Beijing Jiaotong Univ.
Li, Siyuan — North China Univ. of Tech.
Wang, Li — North China Univ. of Tech.
Yin, Hao — North China Univ. of Tech.

▷ FriA07-05
An Improved Multi-agent Model-free Adaptive Iterative Learning Consensus Control under Data Dropouts
Yan, Shuaiming — Big Data Acad., ZhongKe

▷ FriA07-06
Dynamic Modeling and Tracking Control of Underwater Snake Robot
Tao, Baosheng — Tianjin Univ. of Tech.
Sun, Hao — Nankai Univ.
Sun, Junqing — Tianjin Univ. of Tech.

▷ FriA07-07
A PID Controller Based on ESO and Tuning Method
Li, Xiangyang — South China Uni. of Tech
Hu, Yu — Cleveland State Univ.
Gao, Zhiqiang — Cleveland State Univ.
Ai, Wei — South China Univ. of Tech.
Tian, Senping — South China Univ. of Tech.

▷ FriA07-08
SMOTE-Based Fault Diagnosis Method for Unbalanced Samples
Xu, Yuan — Beijing Univ. of Chemical Tech.
Cheng, Xiaoqian — Beijing Univ. of Chemical Tech.
Ke, Wei — Macao Polytechnic Inst.
Zhu, Qunxiong — Beijing Univ. of Chemical Tech.
He, Yan-Lin — Beijing Univ. of Chemical Tech.
Zhang, Yang — Beijing Univ. of Chemical Tech.

▷ FriA07-09
A Fault Prediction System for the Complex Satellite Management System Based on Rule and Fault Tree
Li, Ganhua — Xi'an Satellite Control Center
Fan, Henghai — Xi'an Satellite Control Center
Dong, Li — Xi'an Satellite Control Center
Li, Xianwu — Xi'an Satellite Control Center
Tai, Nengjian — Xi'an Satellite Control Center
Gao, Yaruixi — Xi'an Satellite Control Center
Zhang, Ruolan — Xi'an Satellite Control Center

▷ FriA07-10
IGBT Status Prediction Based on PSO-RF with Time-Frequency Domain Features
Wang, Yizhou — Southwest Jiaotong Univ., Chengdu
Xie, Fei — Southwest Jiaotong Univ.
Zhao, Tianwen — Southwest Jiaotong Univ.
Li, Zhuoran — Southwest Jiaotong Univ.
Li, Mingyue — Southwest Jiaotong Univ.
Liu, Dong — Southwest Jiaotong Univ.

▷ FriA07-11
Outlier Removal of Discontinuous Satellite Telemetry Data Based on Deconvolutional Reconstruction Network
Zhao, Haotian — Harbin Inst. of Tech.
Liu, Ming — Harbin Inst. of Tech.
Luo, Tianyi — Harbin Inst. of Tech.

▷ FriA07-12
Fault Diagnosis of Subway Sliding Plug Door Based on Machine Learning and Motor Current Signal
Huang, Jiaman — Southwest Jiaotong Univ.
Guo, Shenyuan — Southwest Jiaotong Univ.
Jiang, Jierui — SWJTU-Leeds Joint School Southwest Jiaotong Univ.
Shi, Fengjun — South West Jiao Tong Univ.
Wenxiu, Liu — Xihua Univ.
Liu, Dong — Southwest Jiaotong Univ.

▷ FriA07-13
Iterative learning control of a class of complex valued systems described by Schr¨odinger equation
Cai, Liuchi — Guangxi Univ. of Sci. & Tech.
Dai, Xisheng — Guangxi Univ. of Sci. & Tech.,
Zhang, Jianxiang — Jiangnan Univ.
Zuo, Huang — Guangxi Univ. of Sci. & Tech.
Zhang, Jiaming — Guangxi Univ. of Sci. & Tech.

▷ FriA07-14
Quantized Iterative Learning Control for Nonlinear Switched Discrete-time Systems with Actuator Saturation
Sun, Shu-Ting — Sun Yat-sen Univ.
Li, Xiao-Dong — Sun Yat-sen Univ.

▷ FriA07-15
Modeling and Characteristics of Smart Library Knowledge Ecosystem Structure Modeling and Characteristics Based on Super-network
Wei, Qiongqiong — Qingdao Univ. of Sci. & Tech.

▷ FriA07-16
Segmented Adaptive Singular Value Decomposition for Data Compression of IGBT
Qian, Jin — Southwest Jiaotong Univ.

▷ FriA07-17
Prediction of Photovoltaic Power Generation Based on D-vine Copula Model in Typical Climates
Zhang, Ruiyin — Shanghai Univ.
Jia, Li — Shanghai Univ.
Zhou, Yang — Shanghai Univ.

▷ FriA07-18
Improved Path Planning Algorithm Based on RRT Algorithm and Quintic B-spline Curve
Zhao, Duo — Southwest Jiaotong Univ.
Huang, Wendong — Southwest Jiaotong Univ.

▷ FriA07-19
Multi-robot Task Allocation and Rescue for Mowing
Liu, Tengqian — Southwest Jiaotong Univ.
Sun, Yongkui — Southwest Jiaotong Univ.
Song, Weihong — Southwest Jiaotong Univ.
Ma, Lei — Southwest Jiaotong Univ.

▷ FriA07-20
A Robot Relocalization Method Based on Laser and Visual Features
Wang, Enhao — Southwest Jiaotong Univ.
Chen, Dewang — Southwest Jiaotong Univ.
Fu, Tianqi — Southwest Jiaotong Univ.
Ma, Lei — Southwest Jiaotong Univ.

▷ FriA07-21
A Neural Network with Spatial Attention for Pixel-Level Crack Detection on Concrete Bridges
Ji, Wenpeng — Northwestern Polytechnical Univ.
Zhang, Yizhai — Northwestern Polytechnical Univ.
Huang, Panfeng — Northwestern Polytechnical Univ.
Yan, Yuchen — Northwestern Polytechnical Univ.
Yang, Qilei — Northwestern Polytechnical Univ.

▷ FriA07-22
COVID-19 Detection in CXR Image Using High Frequency Emphasis Filtering Based Convolutional Neural Network
Ji, Honghai — North China Univ. of Tech.
Li, Jiaqi — North China Univ. of Tech.
Wang, Li — North China Univ. of Tech.
Fan, Lingling — Beijing Information Sci. & Tech. Univ.
Zhang, Yixiao — Beijing Shiny Tech.Co.,Ltd
Wang, Wei — PowerChina South Construction Investment CO.,LTD

▷ FriA07-23
Thermal Comfort Modeling of Office Buildings Based on Improved Random Forest Algorithm
Zhang, Hongchao — Univ. of Sci. & Tech. Beijing
Yang, Xu — Univ. of Sci. & Tech. Beijing
Tu, Rang — Univ. of Sci. & Tech.
Huang, Jian — Univ. of Sci. & Tech. Beijing
Li, Yiran — Univ. of Sci. & Tech. Beijing

▷ FriA07-24
Adaptive Gaussian Process Regression-Based Remaining Useful Life Prediction of PEMFC Incorporating An Improved Health Indicator
Tang, Lin — Univ. of Sci. & Tech. Beijing
Yang, Xu — Univ. of Sci. & Tech. Beijing
Gao, Jingjing — Univ. of Sci. & Tech. Beijing
Huang, Jian — Univ. of Sci. & Tech. Beijing
Cui, Jiarui — Univ. of Sci. & Tech. Beijing

▷ FriA07-25
Event -Triggered Adaptive Control for Underactuated Surface Vessels

Wang, Qiwen — ShanDong JiaoTong Univ.
Meng, Xiangfei — Shandong Jiaotong Univ.
Zhang, Qiang — Shandong Jiaotong Univ.
Wu, Hengtao — ShanDong JiaoTong Univ.
Wang, Caifan — ShanDong JiaoTong Univ.
Li, Xiaobo — ShanDong JiaoTong Univ.

▷ FriA07-26
A Novel YOLOv5-based Anomalous Object Detection Algorithm in Buses

Liu, Shida — Beijing Jiaotong Univ.
Li, Qingyi — North China Univ. of Tech.
Ji, Honghai — North China Univ. of Tech.
Wang, Li — North China Univ. of Tech.
Zhang, Xiaoping — North China Univ. of Tech.
He, Zhonghe — North China Univ. of Tech.

▷ FriA07-27
Double-Net DDPG with the Optimal Action Selection Mechanism

Li, Dazi — Beijing Univ. of Chemical Tech.
Dong, Caibo — Beijing Univ. of Chemical Tech.

▷ FriA07-28
Optimal Tracking Control of Vehicle Cooperative Platoon Based on Reinforcement Learning

Li, Changcheng — North China Univ. of Tech.

▷ FriA07-29
Low-dimensional Non-linear Luenberger Observer for Thermal Distribution of Wafer in Rapid Thermal Processing Process

Xiao, Tengfei — Sun Yat-Sen Univ.
Kong, Ying — Sun Yat-sen Univ.
Li, Xiao-Dong — Sun Yat-sen Univ.

▷ FriA07-30
Research on Text Data Mining Method of Streaming Media Platform

Chen, Siwei — Southwestern Univ. of Finance & Economics
Xiong, Wenjun — Southwestern Univ. of Finance & Economics

▷ FriA07-31
A Matrix Software Library Method for the Ground System of Space Data Center

Li, Ganhua — Xi'an Satellite Control Center
Fan, Henghai — Xi'an Satellite Control Center
Dong, Li — Xi'an Satellite Control Center
Han, Minzhang — Xi'an Satellite Control Center
Kong, Bo — Xi'an Satellite Control Center
Zhang, Ruolan — Xi'an Satellite Control Center

▷ FriA07-32
Deep Learning Based Closed-loop Identification of Typical Thermal Process Model

Weng, Fanglong — China Ship Development & Design Center
Zhang, Xin — Southeast Univ.
Xue, Yali — Tsinghua Univ.
Sun, Li — Southeast Univ., Http://power.seu.edu.cn/sl/list.htm

▷ FriA07-33
Communication-Efficient Federated Learning with An Event-Triggering Strategy

Li, Yuhao — Beihang
Bai, Junxiang — Beihang Univ.
Li, Duo — Beihang Univ.
Li, Wenling — Beihang Univ.

FriB01 10:10–12:10 Room 1
Invited Session: Data-Based Learning and Control

Organizer: Hui, Yu — Beihang Univ. (BUAA)
Organizer: Lu, Changxin — Beihang Univ.
Organizer: Meng, Deyuan — Beihang Univ. (BUAA)
Organizer: Chi, Ronghu — Qingdao Univ. of Sci. & Tech.
Chair: Hui, Yu — Beihang Univ. (BUAA)
Co-Chair: Lu, Changxin — Beihang Univ.

▶ FriB01-1 10:10–10:30
A Multi-stage Optimized Fault Diagnosis Model for Imbalanced Fault Data in Manufacturing Process

Lai, Zhouhao — Guangdong Univ. of Tech.
Dong, Yan — Guangdong Univ. of Tech.
Ren, Hongru — Guangdong Univ. of Tech.
Lu, Renquan — Guangdong Univ. of Tech.

▶ FriB01-2 10:30–10:50
An Automatic Approach for Aircraft Landing Process Based on Iterative Learning Control

Cui, Shunfeng — Soochow Univ.
Chen, Yiyang — Soochow Univ.
Tao, Hong-Feng — Jiangnan Univ.

▶ FriB01-3 10:50–11:10
Secure and Privacy-Preserving Consensus for Multi-Agent Networks under Deception Attacks

Hu, Qinling — Hangzhou Dianzi Univ.
Wu, Yiming — Hangzhou Dianzi Univ.
Zheng, Ning — Hangzhou Dianzi Univ.
Xu, Ming — Hangzhou Dianzi Univ.
He, Xiongxiong — Zhejiang Univ. of Tech.

▶ FriB01-4 11:10–11:30
Iterative Dynamic Internal Model Based ILC for A Class of Nonlinear Nonaffine Discrete-time Systems

Zhuang, Yongbo — Qingdao Port International Co., Ltd
Zhang, Huimin — Qingdao Univ. of Sci. & Tech.
Chi, Ronghu — Qingdao Univ. of Sci. & Tech.
Wen, Hongjie — Qingdao Port International Co., Ltd

▶ FriB01-5 11:30–11:50
Anomaly Detection Method Based on Sample Constrained Training

Tian, Ying — Bohai Univ.

▶ FriB01-6 11:50–12:10
Neural Network Based Adaptive Consensus Control for A Class of Nonlinear Multi-Agent Systems with Time Delays

Wang, Zuo — Huaqiao Univ.
Chen, Liheng — Harbin Engineering Univ.
Zhu, Yanzheng — Huaqiao Univ.

FriB02 10:10–12:10 Room 3
Invited Session: Intelligent Control for Complex Nonlinear Systems

Organizer: Liang, Hongjing — College of Engineering, Bohai Univ.
Organizer: Liu, Yang — Guangdong Univ. of Tech.
Chair: Liang, Hongjing — College of Engineering, Bohai Univ.
Co-Chair: Liu, Yang — Guangdong Univ. of Tech.

▶ FriB02-1 10:10–10:30
A Quality Prediction Hybrid Model of Manufacturing Process Based on Genetic Programming

Peng, Chong — Guangdong Univ. of Tech.
Cheng, Zhijian — Univ. of Sci. & Tech. of China
Ren, Hongru — Guangdong Univ. of Tech.
Lu, Renquan — Guangdong Univ. of Tech.

▶ FriB02-2 10:30–10:50
Zero-Sum Game for A Class of Second-Order Systems

Ji, Weiyu — Bohai Univ.
Pan, Yingnan — Bohai Univ.
Zhou, Xiaoshuai — Bohai Univ.

▶ FriB02-3 10:50–11:10
An Optimal Sliding Mode Controller Against False Data Injection Attacks

Wu, Chengwei — Harbin Inst. of Tech.
Dong, Bo — The Second Acad. of CASIC
Han, Shuo — Harbin Inst. of Tech.
Yao, Weiran — Harbin Inst. of Tech.

▶ FriB02-4 11:10–11:30
State-dependent Event Triggered Path Following Control of Unmanned Ground Vehicle with Uncertainties

Zhang, Pengfei — Qufu Normal Univ.
Sun, Hongtao — Qufu Normal Univ.
Chen, Ziran — Nanjing Univ. of Sci. & Tech.
Tan, Cheng — Shandong Univ.

▶ FriB02-5 11:30–11:50
Bipartite Consensus Tracking for Stochastic Multi-Agent Systems: A Finite-Time Prescribed Performance Approach

Chen, Lei — Bohai Univ.
Hong, Xue — Bohai Univ.

▶ FriB02-6 11:50–12:10
Fault Detection for T-S Fuzzy Systems with Local Nonlinear Model

Li, Shaoyi — Nanchang Inst. of Sci. & Tech.
Wei, Yanping — Nanchang Inst. of Sci. & Tech.

FriB03 10:10–12:10 Room 4
Regular Session: Data Driven Control (II)

Chair: Pang, Zhonghua — North China Univ. of Tech.
Co-Chair: Song, Yang — Shanghai Univ.

▶ FriB03-1 10:10–10:30

IGBT Massive Data Compression Based on the Adaptive Threshold Wavelet Compression Algorithm
An, Boning — Southwest Jiaotong Univ.
Tian, Xiao — Southwest Jiaotong Univ.
Wang, Jialong — Southwest Jiaotong Univ.
Sui, Zhouli — SWJTU-LEEDS Joint School
Li, Mingyue — Southwest Jiaotong Univ.
Liu, Dong — Southwest Jiaotong Univ.

▶ FriB03-2 10:30–10:50
L_1-stochastic Stability and L_1-gain Control for Positive 2D Markov Jump Systems
Duan, Zhaoxia — Hohai Univ.
Sun, Yue — Hohai Univ.
Xiang, Zhengrong — Guangxi Univ. of Sci. & Tech.

▶ FriB03-3 10:50–11:10
Synchronous Control of Multi-motor Systems Using An Improved Relative Coupling Control Structure
Zheng, Yong — North China Univ. of Tech.
Qu, Hao — North China Univ. of Tech.
Zhao, Yijing — North China Univ. of Tech.
Pang, Zhonghua — North China Univ. of Tech.

▶ FriB03-4 11:10–11:30
Stability Analysis of Continuous-time Switched Systems Based on Jordan Decomposition under Loop-dependent Dwell Time Approach
Yue, Zhang — Shanghai Univ.
Song, Yang — Shanghai Univ.
Zhao, Wanqing — Univ. of East Anglia

▶ FriB03-5 11:30–11:50
Optimal Tracking Control of DC Motors with Partially Unknown Dynamics
Liang, Xianglong — Nanjing Univ. of Sci. & Tech.
Yao, Jianyong — Nanjing Univ. of Sci. & Tech.

▶ FriB03-6 11:50–12:10
Adaptive Model-Free Controller with Supervised Switching Technology of Upper Limb Exoskeleton
Xu, Jiazhen — Nanjing Univ. of Sci. & Tech.
Tian, Yang — Nanjing Univ. of Sci. & Tech.
Wang, Haoping — Nanjing Univ. of Sci. & Tech.
Ma, Xingyu — Nanjing Univ. of Sci. & Tech.
Guo, Yida — Nanjing Univ. of Sci. & Tech.

FriB04 10:10–12:10 Room 5
Regular Session: Neural Networks, Fuzzy Systems Control in Data Driven Manner (I)
Chair: Feng, Jian — Northeasten Univ.
Co-Chair: Liu, Shan — Zhejiang Univ.

▶ FriB04-1 10:10–10:30
A Self-Training Multi-Task Attention Method for NILM
Li, Keqin — Northeastern Univ.
Feng, Jian — Northeasten Univ.
Xing, Yitong — Northeastern Univ.
Wang, Bowen — Northeastern Univ.

▶ FriB04-2 10:30–10:50
Identification Algorithm of Hammerstein Nonlinear System Using Neural Fuzzy Network and State Space Model
Yang, Hao — Jiangsu Univ. of Tech.
Li, Feng — Jiangsu Univ. of Tech.
Cao, Qingfeng — Yangzhou Univ.

▶ FriB04-3 10:50–11:10
An Automatic Detection Approach for Wearing Safety Helmets on Construction Site Based on YOLOv5
Ge, Pengqiang — Soochow Univ.
Chen, Yiyang — Soochow Univ.

▶ FriB04-4 11:10–11:30
Object Pose Estimation Based on Improved YOLOX Algorithm
Zhou, Yanhong — Zhejiang Univ.
Liu, Shan — Zhejiang Univ.

▶ FriB04-5 11:30–11:50
Enhancing EEG Motor Imagery Decoding Performance via Deep Temporal-domain Information Extraction
Yang, Qihong — Chongqing Univ. of Posts & Telecommunications
Yang, Mingzhao — Chongqing Univ. of Posts & Telecommunications
Liu, Ke — Chongqing Unversity of Posts & Telecommunications
Deng, Xin — Chongqing Univ. of Posts & Telecommunications

▶ FriB04-6 11:50–12:10
PMSM Field Orientation Control Based on Online Neuron PID
Zhao, Duo — Southwest Jiaotong Univ.
Cai, Jianchang — Southwest Jiaotong Univ.

FriB05 10:10–12:10 Room 6
Regular Session: Data-driven Fault Diagnosis and Health Maintenance (II)
Chair: Zheng, Ying — Huazhong Univ. of Sci. & Tech.
Co-Chair: Yang, Xu — Univ. of Sci. & Tech. Beijing

▶ FriB05-1 10:10–10:30
Industrial Imbalanced Fault Diagnosis Method Based on Borderline SMOTE Integrated with NPE and CatBoost
Zhu, Qunxiong — Beijing Univ. of Chemical Tech.
Wang, Xinwei — Beijing Univ. of Chemical Tech.
Zhang, Ning — Beijing Univ. of Chemical Tech.
Xu, Yuan — BEIJING Univ. OF CHEMICAL Tech.
He, Yan-Lin — Beijing Univ. of Chemical Tech.

▶ FriB05-2 10:30–10:50
Feature Extraction of Sequence Data Based on LSTM and Its Application to Fault Diagnosis of Industrial Process
Yang, Xiaojun — Tsinghua Univ.
Wan, Chuan — Tsinghua Univ.
Zhang, Tongshuai — Tsinghua Univ.
Xiong, Zhihua — Tsinghua Univ.

▶ FriB05-3 10:50–11:10
A Fault Detection and Isolation Method Based on Supervised Nonnegative Matrix Factorizations
Zhai, Lirong — Liaoning Univ.
Sun, Siqi — Liaoning Univ.
Gao, Zhe — Liaoning Univ.
Weng, Yongpeng — Dalian Maritime Univ.

▶ FriB05-4 11:10–11:30
A Prototypical Networks-based Multi-task Model for Few-shot Fault Diagnosis
Huo, Zhihao — Huazhong Univ. of Sci. & Tech.
Yang, Xiaoyu — Huazhong Univ. of Sci. & Tech.
Yang, Tao — Huazhong Univ. of Sci. & Tech.
Fan, Huijin — Huazhong Univ. of Sci. & Tech.
Su, Housheng — Huazhong Univ. of Sci. & Tech.
Zheng, Ying — Huazhong Univ. of Sci. & Tech.

▶ FriB05-5 11:30–11:50
Fault-Tolerant Control Based on State Observer and Optimal Allocation for Four-Wheel Independent Drive Electric Vehicle
Li, Fengyang — Uestc
Chen, Yong — Univ. of Electronic Sci. & Tech. of China
Tang, Hui — Uestc

▶ FriB05-6 11:50–12:10
Automated Pap Smear Cervical Cancer Detection Based on Multiscale Convolutional Neural Network
Xia, Mingyang — Tianjin Univ.
Zhang, Guoshan — Tianjin Univ.
Guan, Bin — Tianjin Univ.

FriB06 10:10–12:10 Room 7
Regular Session: Neural Networks, Fuzzy Systems Control in Data Driven Manner (II)
Chair: Deng, Xin — Chongqing Univ. of Posts & Telecommunications
Co-Chair: Jin, Huaiping — Kunming Univ. of Sci. & Tech.

▶ FriB06-1 10:10–10:30
Diabetic Retinopathy Diagnosis Based on Transfer Learning and Improved Residual Network
Chai, Rongmin — Beijing Univ. of Chemical Tech.
Chen, Di — Shandong First Medical Univ.
Ma, Xin — Beijing Univ. of Chemical Tech.
Liu, Shengyan — The Second Affiliated Hospital of Shandong First Medical Univ.
Wang, Yi — Shandong First Medical Univ.
Wang, Youqing — Beijing Univ. of Chemical Tech.

▶ FriB06-2 10:30–10:50
Emotion Recognition Method Based on EEG in Few Channels
Deng, Xin — Chongqing Univ. of Posts & Telecommunications
Lv, Xiangwei — Chongqing Univ. of Posts & Telecommunications

Yang, Pengfei Chongqing Univ. of Posts & Telecommunications
Liu, Ke Chongqing Unversity of Posts & Telecommunications
Sun, Kaiwei Chongqing Univ. of Posts & Telecommunications

▶ FriB06-3 10:50–11:10
Integral Sliding Mode Control for Partially Unknown T-S Fuzzy Systems Based on Reinforcement Learning Method
Sun, Xingjian Nantong Univ.
Shi, Min Nantong Univ.
Chen, Nan Nantong Univ.
Gu, Juping Nantong Univ.

▶ FriB06-4 11:10–11:30
Distributed Cooperative Control of High-Speed Trains with Input Saturation and Unmodeled Dynamics
Zhu, Lei Southwest Jiaotong Univ.
Huang, Deqing Southwest Jiaotong Univ.
Li, Xuefang National Univ. of Singapore

▶ FriB06-5 11:30–11:50
Combining Virtual Sample Generation Based Data Enhancement and Multi-objective Optimization Based Selective Ensemble for Soft Sensor Modeling
Huang, Shuqi Kunming Univ. of Sci. & Tech.
Jin, Huaiping Kunming Univ. of Sci. & Tech.
Yang, Biao Kunming Univ. of Sciecnce & T
Liu, Haipeng Kunming Univ. of Sci. & Tech.

▶ FriB06-6 11:50–12:10
Soft Sensing Method Based on Online Dynamic Clustering and Self-labeling
Wang, Yuechen Kunming Univ. of Sci. & Tech.
Jin, Huaiping Kunming Univ. of Sci. & Tech.
Yang, Biao Kunming Univ. of Sciecnce & T
Liu, Haipeng Kunming Univ. of Sci. & Tech.

Poster Session FriB07
Aug. 5, 10:10–12:10
Emei Ballroom

Chair: Ai, Wei South China Univ. of Tech.
Co-Chair: Hu, Chaofang Tianjin Univ.

▷ FriB07-01
Event-Triggered Adaptive NN Control for A Class of Unknown Stochastic Nonlinear Systems under DoS Attacks
Han, Luheng Xidian Univ.
Li, Jing Xidian Univ.

▷ FriB07-02
Extraction Method of Characteristic Indicators for Travel on the Key Corridor
Zhang, Shuai North China Univ. of Tech.
Tan, Jiyuan North China Univ. of Tech. Beijing
Feng, Yan North China Univ. of Tech.
Luo, Wenxiu North China Univ. of Tech.

▷ FriB07-03
Obstacle Avoidance Path Planning and Motion Control for A Multi-joint Soft Manipulator
Cao, Zhiyan Shanghai Univ.
Huang, Tianyu Shanghai Univ.
Bao, Zhiwen Southeast Univ.
Xie, Yangmin Shanghai Univ.
Shi, Hang Shanghai Univ.

▷ FriB07-04
A Review of Research on Intelligent Control Algorithm Applied to Power Line Inspection Robot
Chen, Beining Hohai Univ.
Feng, Yanbo Hohai Univ.
Cao, Yuhan Hohai Univ.

▷ FriB07-05
Model Free Adaptive Traffic Signal Control for Four-phase Intersections
Yin, Hao North China Univ. of Tech.
Ren, Ye Beijing Jiaotong Univ.
Wang, Li North China Univ. of Tech.
Ji, Honghai North China Univ. of Tech.
Liu, Shida Beijing Jiaotong Univ.

▷ FriB07-06
Transformer Fault Diagnosis Based on PSO-RF Characterised by Modified CNN-encoder
Song, Maojia Southwest Jiaotong Univ.
Luo, Yicheng Southwest Jiaotong Univ.
Liu, Shixiao Southwest Jiaotong Univ.
Fan, Jingwei Southwest Jiaotong Univ.
Li, Mingyue Southwest Jiaotong Univ.
Liu, Dong Southwest Jiaotong Univ.

▷ FriB07-07
Defect Detection of Track Fasteners Based on Pruned YOLO V5 Model
Wang, Xinyu Southwest Jiaotong Univ.
Zhang, Jiali Southwest Jiao Tong Univ.
Wang, Yuwei Southwest Jiaotong Univ.
Liu, Dong Southwest Jiaotong Univ.
Li, Mingyue Southwest Jiaotong Univ.

▷ FriB07-08
Remaining Useful Life Prediction of Rolling Bearings Using Correlation Coefficient Based Long Short-Term Memory Neural Network
Wang, Chenyang China Nuclear Power Tech. Research Inst. Co. Ltd
Yin, Chaolin China Nuclear Power Tech. Research Inst. Co. Ltd
Bai, Shan China Nuclear Power Tech. Research Inst. Co. Ltd
Han, Yongming Beijing Univ. of Chemical Tech.

▷ FriB07-09
A Fault Diagnosis Approach Integrated LPP with AROMF for Process Industry
Xu, Yuan Beijing Univ. of Chemical Tech.
Wang, Zixu BUCT
Ke, Wei Macao Polytechnic Inst.
He, Yan-Lin Beijing Univ. of Chemical Tech.
Zhu, Qunxiong Beijing Univ. of Chemical Tech.
Zhang, Yang Beijing Univ. of Chemical Tech.

▷ FriB07-10
Covid-19 Epidemic Trend Prediction Based on CNN-StackBiLSTM
Li, Zhenyu Huazhong Univ. of Tech.
Wang, Yang Huazhong Univ. of Sci. & Tech.
Wang, Yanwei Wuhan Inst. of Tech.
Zheng, Ying Huazhong Univ. of Sci. & Tech.
Su, Housheng Huazhong Univ. of Sci. & Tech.

▷ FriB07-11
A Novel Fault Diagnosis Method Based on Multi-class Probabilistic SVD-D
Zhang, Chuanfang Univ. of Sci. & Tech. Beijing
Peng, Kaixiang Univ. of Sci. & Tech. Beijing
Dong, Jie Univ. of Sci. & Tech. Beijing, China
Ma, Liang Univ. of Sci. & Tech. Beijing
Zhang, Xueyi Univ. of Sci. & Tech. Beijing

▷ FriB07-12
Data-driven Adaptive Optimization Recursive Identification for A Discrete-time Nonlinear System
Liu, Shida Beijing Jiaotong Univ.
Wang, Yulin College of Electronics & Control Engineering, North China Univ. of Tech., Beijing
Fan, Lingling Beijing Information Sci. & Tech. Univ.
Wang, Li North China Univ. of Tech.
Wei, Yuzhou College of Electronics & Control Engineering, North China Univ. of Tech., Beijing
Ji, Honghai North China Univ. of Tech.

▷ FriB07-13
Face Landmark Calibration Based on 3D Reconstruction and Deep Learning
Hu, Boyang North China Univ. of Tech.
Deng, Jinzhao North China Univ. of Tech.
Li, Dan North China Univ. of Tech.
Long, Zhou North China Univ. of Tech.
Sun, Wenhao North China Univ. of Tech.
Zhang, Xiaoping North China Univ. of Tech.
Yan, Jiaqing North China Univ. of Tech.

▷ FriB07-14
Learning Optimization for Dispatch of Interregional Power Grid under Uncertain Environment
Tang, Hao Hefei Univ. of Tech.
Zhang, Yan Hefei Univ. of Tech.
Li, Xiaoqing Hefei Univ. of Tech.

Lv, Kai — Hefei Univ. of Tech.

▷ FriB07-15
Open-loop NARX based Modeling of a Hybrid-electric Turboshaft Engine' s Startup Process
Li, Zhilin — Beijing Inst. of Tech.
Ma, Yue — Beijing Inst. of Tech.

▷ FriB07-16
Data-based Modeling and Simulation of Denso Robotic Arm
Liu, Shoufu — Tianjin Univ.
Dong, Na — Tianjin Univ.
He, Kesen — Tianjin Univ.
Mai, Xiaoming — Tianjin Univ.

▷ FriB07-17
Multi-Model Tube-MPC Fault-Tolerant Control for Flexible Hypersonic Vehicle
Mi, Hanpeng — Tianjin Univ.
Hu, Chaofang — Tianjin Univ.
Yang, Xiaohe — Tianjin Univ.
Hu, Yongtai — Flight Automatic Control Research Inst.

▷ FriB07-18
Global Path Planning Method by Fusion of A-star Algorithm and Sparrow Search Algorithm
Chen, Yangde — Huzhou Univ.
Wang, Peiliang — Huzhou Univ.
Lin, Zichen — Huzhou Univ.
Sun, Chenhao — Huzhou Univ.

▷ FriB07-19
Partition Weighted Delay-timer for Industrial Alarm Monitoring
Xin, Kaiqiang — China Nuclear Power Operation Tech. Corporation, LTD
Ba, Jun — Research Inst. of Nuclear Power Operation

▷ FriB07-20
Automated Classification of Cervical Image Based on Deep Neural Network
Zhao, Mengying — Tianjin Univ. of Tech.
Zhang, Liyan — Tianjin Univ. of Tech.
Wang, Juan — Tianjin Univ. of Tech.
Xia, Chengyi — Tianjin Univ. of Tech.

▷ FriB07-21
Dynamic Obstacle Avoidance Algorithm for Robot Arm Based on Deep Reinforcement Learning
Cheng, Xiaowei — Zhejiang Univ.
Liu, Shan — Zhejiang Univ.

▷ FriB07-22
An Automatic Reflective Clothing Detection Algorithm Based on YOLOv5 for Work Type Recognition
He, Xinyi — JiangNan Univ.
Ma, Ping — Jiangnan Univ.
Chen, Yiyang — Soochow Univ.
Liu, Yuan — Jiangnan Univ.

▷ FriB07-23
Attention Based CNN-LSTM Network for Anomaly Pattern Classification of Multivariate Time Series
Zhang, Xian Bo — Jingdongkeji
Wang, Chao — JD Tech.
Zhang, Jing — JD Tech
Lin, Feng — JD.com, Inc
Li, Zezhou — JDTech

▷ FriB07-24
A Novel Prescribed Performance Control Strategy for Uncertain Nonlinear Systems.
Ju, Jiaying — Shandong Jianzhu Univ.
Liu, Na — Shandong Jianzhu Univ. Architecture & Urban Planning Design Inst.
Liu, Yunlei — Jinan Chengbo Information Tech. Co., Ltd

▷ FriB07-25
Output Regulation for Switched Systems: An Event-triggered Model Predictive Control Approach
Guo, Shitong — Shenyang Aerospace Univ.
Qi, Yiwen — Shenyang Aerospace Univ.
Zhang, Simeng — Shenyang Aerospace Univ.
Tang, Yiwen — Shenyang Aerospace Univ.
Yu, Wenke — Shenyang Aerospace Univ.

▷ FriB07-26
An Improved Multi-agent Based Data Driven Distributed Adaptive Cooperative Control in Traffic Network Signal Timing
Ji, Honghai — North China Univ. of Tech.
Yin, Hu — NCUT
Ren, Ye — Beijing Jiaotong Univ.
Wang, Li — North China Univ. of Tech.
Liu, Shida — Beijing Jiaotong Univ.

▷ FriB07-27
Soft-sensors Based on Gaussian Process Regression for Wastewater Treatment Plants
Liu, Tong — Beijing Univ. of Tech.
Chai, Wei — Beijing Univ. of Tech.
Wang, Congcong — Beijing Univ. of Tech.

▷ FriB07-28
Target Controllability of Multi-agent Systems
Ji, Yanan — Qingdao Univ.
Ji, Zhijian — Qingdao Univ.
Liu, Yungang — Shandong Univ.
Lin, Chong — Qingdao Univ.

▷ FriB07-29
Wavelet Function Based Spectral Model Calibration for Measuring Crystallization Solution via Using ATR-FTIR Spectroscopy
Pei, Xiaojing — Dalian Univ. of Tech.
Liu, Tao — Dalian Univ. of Tech.
Liu, Jingxiang — Dalian Maritime Univ.
Hao, Shoulin — Dalian Univ. of Tech.
Yang, Siwei — Dalian Univ. of Tech.

▷ FriB07-30
Design of Encrypted Secure Wireless Video Real-time Transmission and Storage System Based on 5G Network
Xiao, Hong — Southwest Jiaotong Univ.
Xia, Jingkang — Southwest Jiaotong Univ.
Tang, Guangming — Southwest Jiaotong Univ.
Huang, Deqing — Southwest Jiaotong Univ.

▷ FriB07-31
Semi-active Suspension Control Strategy of High-speed Train Considering Magnetorheological Dampers
Huang, Deqing — Southwest Jiaotong Univ.
Wang, Xinyue — Southwest Jiaotong Univ.,

▷ FriB07-32
Research on Redundant Time Reallocation of Station Based on Minimum Delay
Huang, Deqing — Southwest Jiaotong Univ.
Ni, Chenjia — Southwest Jiaotong Univ.

▷ FriB07-33
Bipartite Tracking Consensus for Multi-Agent Systems with Input Delays and Nonlinear Dynamics
Du, Xiangyang — Tianjin Univ. of Tech. & Education
Li, Weixun — Tianjin Univ. of Tech. & Education
Zhang, Liqiong — Tianjin Univ. of Tech. & Education
Zhang, Limin — Zhongyuan Univ. of Tech.

FriC01 13:30–15:30 Room 1
Invited Session: Data-Driven Adaptive Learning Control for Nonlinear Systems (I)

Organizer: Wang, Shubo — Qingdao Univ.
Organizer: Na, Jing — Kunming Univ. of Sci. & Tech.
Organizer: Chen, Qiang — Zhejiang Univ. of Tech.
Chair: Wang, Shubo — Qingdao Univ.
Co-Chair: Na, Jing — Kunming Univ. of Sci. & Tech.

▶ FriC01-1 13:30–13:50
Multi-innovation Parameter Identification Based on Coupling Auxiliary Model for Three-axis Turntable
Wang, Minlin — Beijing Inst. of Tech.
Dong, Xueming — Department of Inertia
Ren, Xuemei — Beijing Inst. of Tech.

▶ FriC01-2 13:50–14:10
Trajectory Tracking Control of Nonlinear Singularly Perturbed Systems with Disturbances
Zheng, Dongdong — Beijing Inst. of Tech.
Li, Weixing — Beijing Inst. of Tech.
Ren, Xuemei — Beijing Inst. of Tech.

▶ FriC01-3 14:10–14:30
Adaptive Estimation for Quantized Nonlinear Cascade System
Li, Linwei — Zhengzhou Univ. of Light Industry
Wang, Fengxian — Zhengzhou Univ. of Light Industry
Ren, Xuemei — Beijing Inst. of Tech.

▶ FriC01-4 14:30–14:50
Adaptive Optimal Controls for Multi-Driving Gear of Long-Wall Shearer
Li, Zhien — TISCO Electric Co.,Ltd
Zhao, Jun — Kunming Univ. of Sci. & Tech.
Jian, Long — Taiyuan Univ. of Tech.
Lv, Yongfeng — Taiyuan Univ. of Tech.

▶ FriC01-5 14:50–15:10
Finite-Time Approximation-Free Control for Attitude Tracking of Rigid Spacecraft
Xie, Shuzong — College of Information Engineering, Zhejiang Univ. of Tech.
Chen, Qiang — Zhejiang Univ. of Tech.
He, Xiongxiong — Zhejiang Univ. of Tech.
Ou, Xianhua — Zhejiang Univ. of Tech.

▶ FriC01-6 15:10–15:30
Hybrid Unscented Kalman Filter Design with Data-driven Schedule
Li, Gengen — Kunming Univ. of Sci. & Tech.
Yang, Chunxi — Kunming Univ. of Sci. & Tech.
Gao, Guanbin — Kunming Univ. of Sci. & Tech.
Han, Shichang — Kunming Univ. of Sci. & Tech.
Chen, Fei — Kunming Univ. of Sci. & Tech.

FriC02 13:30–15:30 Room 3
Regular Session: Deep Neural Network and Reinforcement Learning Control
Chair: Song, Ruizhuo — Univ. of Sci. & Tech. Beijing
Co-Chair: Shi, Jia — Xiamen Univ.

▶ FriC02-1 13:30–13:50
A Hybrid Deep Learning Model for the Blood Glucose Prediction
Lu, Xiang — Univ. of Sci. & Tech. Beijing
Song, Ruizhuo — Univ. of Sci. & Tech. Beijing

▶ FriC02-2 13:50–14:10
Two Dimensional (2D) Feedback Control Scheme Based on Deep Reinforcement Learning Algorithm for Nonlinear Non-repetitive Batch Processes
Liu, Jianan — Xiamen Univ.
Hong, Wenjing — Xiamen Univ.
Shi, Jia — Xiamen Univ.

▶ FriC02-3 14:10–14:30
SIM: A Scenario IMagination Based Deep Reinforcement Learning Method for Outdoor Transportation Environment Exploration
Li, Haoran — Univ. of Chinese Acad. of Sci.
Zhang, Qichao — Chinese Acad. of Sci.
Chen, Yaran — Chinese Acad. of Sci.
Zhao, Dong-Bin — Inst. of Automation

▶ FriC02-4 14:30–14:50
Nonlinear Approximate Optimal Control Based on Integral Reinforcement Learning
Tian, Fenming — Jiangnan Univ.
Liu, Fei — Jiangnan Univ., China

▶ FriC02-5 14:50–15:10
Neural Network-based Adaptive Sliding Mode Control for Cricket Systems
Sun, Chuanbin — Qingdao Univ.
Wang, Shubo — Qingdao Univ.
Liu, Yi-Jian — Qingdao Univ.

▶ FriC02-6 15:10–15:30
Distributed Q-Learning for Stochastic LQ Control with Unknown Noise
Zhang, Zhaorong — The Hong Kong Polytechnic Univ.
Xu, Juanjuan — Shandong Univ.

FriC03 13:30–15:30 Room 4
Invited Session: Data-driven Modeling and Adaptive ILC
Organizer: Chen, Qiang — Zhejiang Univ. of Tech.
Organizer: Kong, Ying — Zhejiang Univ. of Tech.
Organizer: Li, He — Zhejiang Univ. & Tech.
Organizer: Yan, Qiuzhen — Zhejiang Univ. of Water Resources & Electric Power
Chair: Chen, Qiang — Zhejiang Univ. of Tech.
Co-Chair: Wei, Qinglai — Inst. of Automation

▶ FriC03-1 13:30–13:50
A Repeatable Motion Scheme for Kinematic Control of Redundant Manipulators
Zhou, Junwen — Zhejiang Univ. of Sci. & Tech.
Wu, Jiajia — Zhejiang Univ. of Sci. & Tech.
Chen, Shiyong — Zhejiang Univ. of Sci. & Tech.
Kong, Ying — Zhejiang Univ. of Tech.

▶ FriC03-2 13:50–14:10
CCANet: Classifcation of Colorectal Tumor Histopathological Images Using A CNN with Channel Attention Mechanisms
Zhang, Licheng — Zhejiang Univ. of Tech.
Cao, Fakun — Zhejiang Univ. of Techonology
Cao, Jing — Zhejiang Univ. of Tech.
Zhu, Beibei — Zhejiang Univ. of Tech.
Li, Sheng — Zhejiang Univ. of Tech.
He, Xiongxiong — Zhejiang Univ. of Tech.

▶ FriC03-3 14:10–14:30
An Adaptive Integral Sliding Mode Control with Allocation Scheme for Reconfigurable Flight Array
Yang, Jianquan — Kunming Univ. of Sci. & Tech.
Yang, Chunxi — Kunming Univ. of Sci. & Tech.
Na, Jing — Kunming Univ. of Sci. & Tech.
Li, Yiming — Kunming Univ. of Sci. & Tech.
Xing, Yashan — Kunming Univ. of Sci. & Tech.

▶ FriC03-4 14:30–14:50
Adaptive Iterative Learning Control for Electromechanical Systems Performing Iteration-varying Tasks
Shi, Huihui — Zhejiang Univ. of Tech.
Chen, Qiang — Zhejiang Univ. of Tech.
He, Xiongxiong — Zhejiang Univ. of Tech.
Ou, Xianhua — Zhejiang Univ. of Tech.

▶ FriC03-5 14:50–15:10
Adaptive Iterative Learning Control for Nonlinear Systems with Time-Iteration-Varying Parametric Uncertainties and Nonparametric Uncertainties
Hong, Zheng — Zhejiang Univ. of Water Resources & Electric Power
Yan, Qiuzhen — Zhejiang Univ. of Water Resources & Electric Power
Cai, Jianping — Zhejiang Univ. of Water Resources & Electric Power
Chen, Qiang — Zhejiang Univ. of Tech.

▶ FriC03-6 15:10–15:30
Data-Driven Optimal Control for Half-Vehicle Suspension System via Adaptive Dynamic Programming
Li, Hongyang — Chinese Acad. of Sci.
Wei, Qinglai — Inst. of Automation

FriC04 13:30–15:30 Room 5
Invited Session: RNN for Signal Processing and Its Applications
Organizer: Sun, Zhongbo — Changchun Univ. of Tech.
Organizer: Shi, Yang — Yangzhou Univ.
Organizer: Jin, Long — Lanzhou Univ.
Chair: Sun, Zhongbo — Changchun Univ. of Tech.
Co-Chair: Jin, Long — Lanzhou Univ.

▶ FriC04-1 13:30–13:50
Path Planning for Upper Limb Rehabilitation Based on Human Motion Feature Output
Yan, Yangben — Changchun Univ. of Tech.
He, Tianyu — Changchun Univ. of Tech.
Liu, Yongbai — Changchun Univ. of Tech.
Wang, Gang — Changchun Univ. of Tech.
Liu, Keping — Changchun Univ. of Tech.
Sun, Zhongbo — Changchun Univ. of Tech.

▶ FriC04-2 13:50–14:10

Rehabilitation Path Planning Based on Human Motion Output and Ergonomic Index Optimization

He, Tianyu — Changchun Univ. of Tech.
Yan, Yangben — Changchun Univ. of Tech.
Wang, Gang — Changchun Univ. of Tech.
Liu, Yongbai — Changchun Univ. of Tech.
Liu, Keping — Changchun Univ. of Tech.
Sun, Zhongbo — Changchun Univ. of Tech.

▶ FriC04-3 14:10–14:30

Performance Analyses of Discrete-Time RNN for Solving Discrete-Form Time-Variant Matrix Inversion with Different Selection Parameters

Shi, Yang — Yangzhou Univ.
Fu, Shengshen — YangzhouUniv.
Ding, Chenling — Yangzhou Univ.
Li, Jian — Xinyang Normal Univ.
Gerontitis, Dimitrios — Aristotle Univ.

▶ FriC04-4 14:30–14:50

Discrete-time Recurrent Neural Network Algorithm with Different Discretization Formulas for Finding Solution of Discrete-Time Complex Division

Shi, Yang — Yangzhou Univ.
Lu, Jiwen — Yangzhou Univ.
Zhao, Wenhan — Yangzhou Univ.
Sheng, Wangrong — Yangzhou Univ.
Li, Jian — Xinyang Normal Univ.
Gerontitis, Dimitrios — Aristotle Univ.

▶ FriC04-5 14:50–15:10

Kinematics Solution Analysis of 6R Robot Based on Spinor Exponential Product

Zhang, Ziqiang — Changchun Univ. of Sci. & Tech.
Cao, Guohua — Changchun Univ. of Sci. & Tech.
Li, Xiaozhou — Changchun Univ. of Sci. & Tech.
Zhang, Bangcheng — Changchun Univ. of Tech.

▶ FriC04-6 15:10–15:30

Dynamic Fault Detection Based on Variational Bayesian Mixture Probabilistic Principal Component Analysis

Huang, Chenghong — ChongQing Univ.
Chai, Yi — Chongqing Univ.
Wei, Chihang — Hangzhou Normal Univ.
Zhu, Zheren — Zhejiang Univ.

FriC05 13:30–15:30 Room 6

Invited Session: Data-driven Virtual-sensor: Algorithm, Architectures and Applications

Organizer: Zhang, Xinmin — Zhejiang Univ.
Organizer: Zhou, Le — Zhejiang Univ. of Sci. & Tech.
Chair: Zhang, Xinmin — Zhejiang Univ.
Co-Chair: Zhou, Le — Zhejiang Univ. of Sci. & Tech.

▶ FriC05-1 13:30–13:50

Deep Learning of Process Data with Supervised Variational Autoencoder for Soft Sensor

Tang, Xiaochu — Shenyang Aerospace Univ.
Yan, Jiawei — Shenyang Aerospace Univ.
Song, Zhihuan — Zhejiang Univ.
Zhang, Xinmin — Zhejiang Univ.

▶ FriC05-2 13:50–14:10

Yarn-dyed Shirt Piece Defect Detection Based on U-shaped Swin Transformer Auto-encoder

Zhang, Hongwei — Zhejiang Univ.
Xiong, Wenbo — Xi'an Polytechnic Univ.
Zhang, Weiwei — Xi'an Polytechnic Univ.
Lu, Shuai — Beijing Univ. of Chemical Tech.

▶ FriC05-3 14:10–14:30

Novel Multimode Process Soft Sensing Methods Based on the Dynamic Mixture Variational Autoencoder Regression Model

Cui, Linlin — Zhejiang Univ.
Yao, Le — Zhejiang Univ.
Ge, Zhiqiang — Zhejiang Univ.
Song, Zhihuan — Zhejiang Univ.

▶ FriC05-4 14:30–14:50

Stacked Denoising Autoencoders Based Poisson Regression for Count Data Modeling

Zhang, Xinmin — Zhejiang Univ.
Liu, Ying — Zhejiang Univ.
Song, Zhihuan — Zhejiang Univ.
Zhu, Zheren — Zhejiang Univ.
Wei, Chihang — Hangzhou Normal Univ.

▶ FriC05-5 14:50–15:10

Distributed Linear Dynamical System for Learning from Massive and Inconsecutive Time-Series Data and Its Application to Industrial Predictive Modeling

Shao, Weiming — China Univ. of Petrolieum

▶ FriC05-6 15:10–15:30

Layer-wise Feature Extraction Approaches with Deep PLS for Quality Prediction in Industrial Process

Yuan, Xiaofeng — Zhejiang Univ.
Xu, Weiwei — Central South Univ.
Wang, Kai — Central South Univ.
Wang, Ya-Lin — Central South Univ.

FriC06 13:30–15:30 Room 7

Regular Session: ADRC and Robust Control

Chair: Chen, Sen — Shaanxi Normal Univ.
Co-Chair: Xue, Wenchao — Chinese Acad. of Sci.

▶ FriC06-1 13:30–13:50

A Robust Control Scheme for Autonomous Vehicles Path Tracking under Unreliable Communication

Zhang, Kun — Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.
Zhang, Huaguang — Northeastern Univ., China
Xue, Wenchao — Chinese Acad. of Sci.
Zhang, Ran — Beihang Univ.

▶ FriC06-2 13:50–14:10

Dynamical Design of ADRC for One-DOF Manipulator Systems with Time-varying Disturbance and Large Parametric Uncertainty

Jiang, He — Shaanxi Normal Univ.
Wu, Yinsuo — Shaanxi Normal Univ.
Bai, Wenyan — Acad. of Mathematics & Sys. Sci.,UCAS
Chen, Sen — Shaanxi Normal Univ.
Zhao, Zhiliang — Shaanxi Normal Univ.

▶ FriC06-3 14:10–14:30

A Novel ADRC Design with Cascade of Observers for Rigid-body Motion Control Systems

Chen, Zhixiang — Qingzhou Hi-tech
Xue, Wenchao — Chinese Acad. of Sci.
Mi, Wenpeng — Qingzhou Hi-tech
Kong, Xiangtong — Qingzhou Hi-tech
Bai, Wenyan — Acad. of Mathematics & Sys. Sci.,UCAS

▶ FriC06-4 14:30–14:50

GA Optimized Fuzzy PID Control with Modified Smith Predictor for HVAC Terminal Fan System

Xie, Renyu — Zhejiang Univ.
Zhang, Tao — Zhejiang Univ.
Jiao, Xuguo — Qingdao Univ. of Tech.
Yang, Qinmin — Zhejiang Univ.

▶ FriC06-5 14:50–15:10

Computer Simulation and Artificial Intelligence Driven Frameworks for Stability Analysis of Spacecraft Phase Plane Control Systems

Chen, Zhihua — Beijing Inst. of Control Engineering
Luo, Ruizhi — Beijing Inst. of Control Engineering
Liu, Wangkui — Harbin Inst. of Tech.
Guo, Jinhua — China Acad. of Launch Vehicle Tech.
Li, Yong — Beijing Inst. of Control Engineering
Guo, Yong — Northwestern Polytechnical Univ.
Zhang, Kai — Sichuan Univ.
Xie, Yongchun — Beijing Inst. of Control Engineering

▶ FriC06-6 15:10–15:30

Model Free Adaptive Tracking Control of Multi-cascade Connection Systems with Switching Topology

Zhang, Zhipeng — Beiing Information Sci. & Tech. Univ.
Xiong, Shuangshuang — Beijing Information & Tech. Univ.
Hou, Zhongsheng — Beijing Jiaotong Univ.

FriD01 15:40–17:40 Room 1
Invited Session: Data-Driven Adaptive Learning Control for Nonlinear Systems (II)

Organizer: Wang, Shubo — Qingdao Univ.
Organizer: Na, Jing — Kunming Univ. of Sci. & Tech.
Organizer: Chen, Qiang — Zhejiang Univ. of Tech.
Chair: Wang, Shubo — Qingdao Univ.
Co-Chair: Na, Jing — Kunming Univ. of Sci. & Tech.

▶ FriD01-1 15:40–16:00
USDE-Based Cascade Control for Servo Motor Systems with Uncertain Dynamics
Shi, Zhenghao — Kunming Univ. of Sci. & Technolog
Huang, Yingbo — Kunming Univ. of Sci. & Tech.
Na, Jing — Kunming Univ. of Sci. & Tech.

▶ FriD01-2 16:00–16:20
Fast Configuration Identification and Matching Gains of RFA Based on Deep Learning Technology
Peng, Yong — Kunming Univ. of Sci. & Tech.
Yang, Chunxi — Kunming Univ. of Sci. & Tech.
Li, Yiming — Kunming Univ. of Sci. & Tech.
Na, Jing — Kunming Univ. of Sci. & Tech.

▶ FriD01-3 16:20–16:40
Nonlinear Gain Extended State Observer Based Nonsmooth Funnel Control for Nonlinear Systems with Unknown Dynamics
Cheng, Yun — Beijing Inst. of Tech.
Ren, Xuemei — Beijing Inst. of Tech.

▶ FriD01-4 16:40–17:00
Adaptive Command Filtered Control of Uncertain Nonlinear System with Friction Input
Sun, Guofa — Qingdao Univ. of Tech.
Zhang, Guoju — Qingdao Univ. of Tech.
Zhao, Erquan — Qingdao Univ. of Tech.
Huang, Ming Yu — Qingdao Univ. of Tech.

▶ FriD01-5 17:00–17:20
Identification of Cogging Force in Ironed Linear Motor Based on RBF Neural Networks Using Hybrid Self-Adaptive TLBO
Chen, Siwen — Harbin Inst. of Tech.
Liu, Yang — Harbin Inst. of Tech.
Song, Fazhi — Harbin Inst. of Tech.

▶ FriD01-6 17:20–17:40
Hysteresis Feedforward Compensation of Reluctance Actuator: A Neural Network Approach Using Stochastic Configuration Network
Liu, Yang — Harbin Inst. of Tech.
Miao, Qian — Harbin Inst. of Tech.
Li, Li — Harbin Inst. of Tech.

FriD02 15:40–17:40 Room 3
Regular Session: Statistical Learning and Machine Learning in Automation Field (II)

Chair: Li, Sheng — Zhejiang Univ. of Tech.
Co-Chair: Zhang, Xiaoping — North China Univ. of Tech.

▶ FriD02-1 15:40–16:00
The Graphical Analysis for Controllability of Multi-agent System Based on Equitable Partition
Su, Mengmeng — Qingdao Univ.
Ji, Zhijian — Qingdao Univ.

▶ FriD02-2 16:00–16:20
BE-Net:Boudary-Enhanced Networks for Accurate Gland Segmentation
Fan, Zhenbang — Zhejiang Univ. of Tech.
Dong, Sheng — Zhejiang Univ. of Tech.
Shi, Shuling — School of Information Engineering
Yang, Wenqin — Zhejiang Univ. of Tech.
Li, Sheng — Zhejiang Univ. of Tech.
He, Xiongxiong — Zhejiang Univ. of Tech.

▶ FriD02-3 16:20–16:40
Spatial-Temporal Attention Transformer Model for Future Trajectory Forecast
Geng, Zhiqiang — Beijing Univ. of Chemical Tech.
Zhang, Te — Beijing Univ. of Chemical Tech.
Han, Yongming — Beijing Univ. of Chemical Tech.

▶ FriD02-4 16:40–17:00
Research on Real-time Road Crack Detection Algorithm Based on Improved Knowledge Distillation
Jiang, Yanyu — North Minzu Univ.
Wei, Haicheng — North Minzu Univ.
Wang, Suo — Northern Univ. for Nationalities
Tian, Siyuan — North Minzu Univ.

▶ FriD02-5 17:00–17:20
Architecture Growth of Dynamic Feedforward Neural Network Based on the Growth Rate Function
Zhang, Xiaoping — North China Univ. of Tech.
Yang, Tianhang — North China Univ. of Tech.
Wang, Li — North China Univ. of Tech.
Liu, Shida — Beijing Jiaotong Univ.
Yan, Jiaqing — North China Univ. of Tech.
He, Zhonghe — North China Univ. of Tech.

▶ FriD02-6 17:20–17:40
Spatio-Temporal View GAIN for Data Imputation and Dynamic Soft Sensor
Ren, Jiayi — Zhejiang Univ.
Chen, Xu — Zhejiang Univ.
Zhao, Chunhui — Zhejiang Univ.

FriD03 15:40–17:40 Room 4
Invited Session: New Trends on Data-driven Control, Learning and Detection for Complex Systems

Organizer: Li, Jinna — Liaoning Shihua Univ.
Organizer: Lang, Xianming — Liaoning Petrochemical Univ.
Chair: Li, Jinna — Liaoning Shihua Univ.
Co-Chair: Lang, Xianming — Liaoning Petrochemical Univ.

▶ FriD03-1 15:40–16:00
Stabilizing Control of Markovian Jump Systems with Switching and State Signal Data Sampling under Denial-of-Service
Wang, Guoliang — Liaoning Shihua Univ.
Ren, Yunshuai — Liaoning Petrochemical Univ.

▶ FriD03-2 16:00–16:20
Rolling Bearing Fault Diagnosis Based on Mixed Data Feature Undirected Graph
Wang, Guoliang — Liaoning Shihua Univ.
Ren, Xueyu — Liaoning Petrochemical Univ.

▶ FriD03-3 16:20–16:40
Consensus of Nonlinear Multi-agent Systems with Uncertainties Using Reinforcement Learning Based Sliding Mode Control
Yuan, Lin — Liaoning Petrochemical Univ.
Li, Jinna — Liaoning Shihua Univ.

▶ FriD03-4 16:40–17:00
Sliding Mode Control Based Consensus of Discrete-time Nonlinear Multi-agent Systems
Yuan, Lin — Liaoning Petrochemical Univ.
Li, Jinna — Liaoning Shihua Univ.

▶ FriD03-5 17:00–17:20
Pipeline Leak Detection Method Based on DTWSVM
Lang, Xianming — Liaoning Petrochemical Univ.
Zhu, Yongqiang — Liaoning Petrochemical Univ.
Cai, Zefeng — North China Air Traffic Management Bureau CAAC

▶ FriD03-6 17:20–17:40
Magnetic Flux Leakage Image Recognition Method of Pipeline Defects Based on Low-level Feature Fusion Multi-core Convolution Neural Network
Lang, Xianming — Liaoning Petrochemical Univ.
Han, Fucheng — Liaoning Petrochemical Univ.
Cai, Zefeng — North China Air Traffic Management Bureau CAAC

FriD04 15:40–17:40 Room 5
Invited Session: Physics/Knowledge-Informed Learning in Process Data Analytics

Organizer: Liu, Yi — Zhejiang Univ. of Tech.
Organizer: Yao, Yuan — National Tsing Hua Univ.
Organizer: Yang, Tao — Northeastern Univ.
Chair: Liu, Yi — Zhejiang Univ. of Tech.
Co-Chair: Yang, Tao — Northeastern Univ.

▶ FriD04-1 15:40–16:00
Particle Filter Based Robust State and Parameter Estimation for Estimating SOC and Discharge Current of Lithium Batteries
He, Yijia — Wenzhou Univ.
Hong, Zhihui — Wenzhou Univ.
Zhang, Zhengjiang — Wenzhou Univ.
Huang, Shipei — Nanjing Univ. of Sci. & Tech.

▶ FriD04-2 16:00–16:20
Pseudo-label Estimation Based on EDA for Semi-supervised Soft Sensor Development
Rao, Feihong — Kunming Univ. of Sci. & Tech.
Jin, Huaiping — Kunming Univ. of Sci. & Tech.
Liu, Haipeng — Kunming Univ. of Sci. & Tech.
Yang, Biao — Kunming Univ. of Sciecnce & T

▶ FriD04-3 16:20–16:40
Adaptive Ensemble Model for Ultra-short-term Wind Power Forecasting
Li, Yunlong — Faculty of Information Engineering & Automation, Kunming Univ. of Sci. & Tech.
Jin, Huaiping — Kunming Univ. of Sci. & Tech.
Liu, Haipeng — Kunming Univ. of Sci. & Tech.
Jin, Huaikang — Huaneng Renewables Co.,Ltd.Yunnan Branch
Cao, Yundong — Huaneng Renewables Co., Ltd. Yunnan Branch

▶ FriD04-4 16:40–17:00
Topology-Informed Graph Convolutional Network for Fault Diagnosis
Jia, Mingwei — Zhejiang Univ. of Tech.
Xu, Danya — Northeastern Univ.
Yang, Tao — Northeastern Univ.
Yao, Yuan — National Tsing Hua Univ.
Liu, Yi — Zhejiang Univ. of Tech.

▶ FriD04-5 17:00–17:20
Fault Root Diagnosis of Industrial Process Based on Random Forest-Partial Symbol Transfer Entropy
Zhu, Yu-Rong — Shanghai Univ.
Wang, Jian-Guo — Shanghai Key Lab of Power Station Automation Tech., Shanghai Univ.
Su, Jing Ru — Shanghai Univ.
Yao, Yuan — National Tsing Hua Univ.
Zhang, Liu-Wei — Shanghai Univ.
Chen, He-Lin — Baoshan Iron & Steel Co. Ltd

▶ FriD04-6 17:20–17:40
Multi-time Scale Granger Causality Analysis for Disturbance Diagnosis
Yu, Guo-Yuan — Shanghai Univ.
Wang, Jian-Guo — Shanghai Key Lab of Power Station Automation Tech., Shanghai Univ.
Ye, Xiangyun — Shanghai Univ.
Yao, Yuan — National Tsing Hua Univ.
Zhang, Liu-Wei — Shanghai Univ.
Chen, He-Lin — Baoshan Iron & Steel Co. Ltd

FriD05 15:40–17:40 Room 6
Invited Session: Data-Driven Security Control for Networked Control Systems
Organizer: Che, Wei-Wei — Qingdao Univ.
Organizer: Ma, Yongsheng — Qingdao Univ.
Chair: Che, Wei-Wei — Qingdao Univ.
Co-Chair: Ma, Yongsheng — Qingdao Univ.

▶ FriD05-1 15:40–16:00
Adaptive Fuzzy Asymptotic Tracking Control for Fractional-Order Nonlinear Systems with Nonstrict-Feedback Structure
Li, Xiao — Qingdao Univ.
Li, Yuan Xin — Liaoning Univ. of Tech.
Che, Wei-Wei — Qingdao Univ.

▶ FriD05-2 16:00–16:20
Event-triggered Adaptive Neural Network Asymptotic Control for Non-triangular Stochastic Nonlinear Systems
Liu, Yongchao — Harbin Engineering Univ.
Zeng, Bowen — Harbin Engineering Univ.

▶ FriD05-3 16:20–16:40
Proportional-integral Interval Observer for Linear Continuous-time Systems
Zhang, Tu — Nanjing Tech Univ.
Wu, Xingzheng — Nanjing Tech Univ.
Li, Liwei — Northeastern Univ.
Shen, Mouquan — Nanjing Tech Univ.

▶ FriD05-4 16:40–17:00
Tracking Control for Constrained Nonlinear Systems
Zhu, Lin — Qingdao Univ.
Yue, Bai-Fan — Qingdao Univ.
Che, Wei-Wei — Qingdao Univ.

▶ FriD05-5 17:00–17:20
Event-Triggered Optimal Containment Control for Multi-Agent Systems with State Constraints by Reinforcement Learning
Wang, Lijie — Qingdao Univ.
Xu, Jiahong — Bohai Univ.
Liu, Yang — Guangdong Univ. of Tech.

▶ FriD05-6 17:20–17:40
Model-Free Adaptive Sliding Mode Control for Discrete-Time Nonlinear Systems with Sensor Fault and Prescribed Performance
Hao, Li-Ying — Dalian Maritime Univ.
Yang, Sen — Dalian Marine Time Univ.
Liu, Dong — Shenyang Aerospace Univ.

FriD06 15:40–17:40 Room 7
Regular Session: Data-driven Technique and Its Industrial Application
Chair: Chen, Yong — Univ. of Electronic Sci. & Tech. of China
Co-Chair: Li, Yan — Shandong Univ.

▶ FriD06-1 15:40–16:00
Energy Balance Based Attack Detection for Cyber Physical Systems
Li, Zhuyuan — Peking Univ.
Yang, Ying — Peking Univ.
Zhao, Zhengen — Nanjing Univ. of Aeronautics & Astronautics
Liu, Ruijie — Univ. of Shanghai for Sci. & Tech.

▶ FriD06-2 16:00–16:20
Data-driven Unscented Kalman Filter for State of Charge Estimation of Li-ion Batteries
Xu, Huiqin — Shandong Univ.
Li, Yan — Shandong Univ.
Yu, Meijuan — Shandong Univ.

▶ FriD06-3 16:20–16:40
Event-Triggered Sliding-Mode Cruise Control for Multibody High-Speed Train
Yu, Wei — Southwest Jiaotong Univ.
Huang, Deqing — Southwest Jiaotong Univ.
Cai, Liangcheng — Southwest JiaoTong Univ.
Wu, Yue — Southwest Jiaotong Univ.

▶ FriD06-4 16:40–17:00
Adaptive Optimal Control of Completely Unknown Systems with Relaxed PE Condition
Luo, Rui — Univ. of Electronic Sci. & Tech. of China
Peng, Zhinan — Univ. of Electronic Sci. & Tech. of China
Hu, Jiangping — Univ. of Electronic Sci. & Tech. of China
Ghosh, Bijoy — Texas Tech Univ.

▶ FriD06-5 17:00–17:20
Detecting Incipient Fault Using Wasserstein Distance
Lu, Cheng — China Jiliang Univ.
Zeng, Jiusun — China Jiliang Univerisity
Luo, Shihua — Jiangxi Univ. of Finance & Economics
Kruger, Uwe — Rensselaer Polytechnic Inst.

▶ FriD06-6 17:20–17:40
Attention-based Stacked Supervised Poisson Autoencoders for Defects Prediction in Casting-rolling Process
Zhang, Xinmin — Zhejiang Univ.
Song, Zhihuan — Zhejiang Univ.
Ge, Zhiqiang — Zhejiang Univ.

Book of Abstracts

Thursday, August 4, 2022

ThurA01 13:30–15:30 Room 1
Regular Session: Iterative Learning Control (I)

Chair: Dai, Xisheng — Guangxi Univ. of Sci. & Tech.,
Co-Chair: Tian, Senping — South China Univ. of Tech.

▶ ThurA01-1 13:30–13:50
State Consistency Tracking for A Class of Singular Multi-agent System Based on Iterative Learning Method

Liu, Hengheng — Sourth China Univ. of Tech.
Tian, Senping — South China Univ. of Tech.
Li, Xiangyang — South China Uni. of Tech
Luo, Rui — South China Univ. of Tech.

In this paper, the iterative learning method is used to study the state consistency tracking problem of a class of singular multi-agent system with fixed initial deviation. Based on the equivalent constraint decomposition form of singular multi-agent systems, an iterative learning control algorithm is proposed. The results show that the state tracking error decreases with time when the initial state deviation exists. In order to further eliminate the influence of initial state deviation, an iterative learning control algorithm with initial correction strategy is proposed to realize the complete tracking of the state to the target in a certain period of time. Finally, simulation example shows the effectiveness of the algorithm.

▶ ThurA01-2 13:50–14:10
Containment Control via Iterative Learning of Singular Multi-agent Systems with Multiple Leaders

Yang, Sizhe — South China Univ. of Tech.
Liu, Qian — Yantai Univ.
Tian, Senping — South China Univ. of Tech.
Li, Xiangyang — South China Uni. of Tech

We study about singular systems' containment control problem, whose followers and leaders have multiple roles, via iterative learning control (ILC) theory in continuous-time domain. Based on the directed graph illustrating the communication between followers and leaders, via state containment errors, we construct a closed-loop iterative learning control algorithm, whose convergence conditions are analyzed in this paper. By using the algorithm, it can be guaranteed that, within a finite temporal interval, the containment errors between the followers' states and the convex hull that leaders' states forms are bounded. And furthermore, if there are no initial errors, state containment errors will approach zero when there are enough iterations. Then the provided examples demonstrate the theoretical results' validity.

▶ ThurA01-3 14:10–14:30
Group Consensus for First-order Multi-agent Systems by the Iterative Learning Control

Wang, Ruige — Xidian Univ.
Li, Jinsha — Xidian Univ.

This paper studies the group consensus for multi-agent systems with linear dynamics and directed graphs. Through iterative learning control algorithm, the followers can track their own leaders in a limited time interval. First, under the assumption that both subgroups satisfy the in-degree balance, this paper defines a reasonable general group consensus error for the first-order multi-agent systems with two subgroups. In addition, we define distributed initial state learning laws, and assume that all interactive agents are globally reachable. Next, sufficient conditions for group consensus are given. Then, this conclusion is extended to first-order multi-agent systems with multiple subgroups, and sufficient conditions are obtained. Finally, the effectiveness of the theories are verified by two simulation examples.

▶ ThurA01-4 14:30–14:50
Weld Seam Extraction of Intersecting Pipelines Based on Point Cloud Entropy

Lu, Shuaibing — ShanDong Univ.
Shi, Xiaorui — SINOTRUK Jinan Power Co.,Ltd
Tian, Xincheng — Shandong Univ.
Liu, Yan — Shandong Univ.

This paper presents a method for extracting intersecting pipelines weld seam based on point cloud. Firstly, the collected point cloud is filtered by PassThrough filter to extract the region of interest, and the intersecting pipelines model is reconstructed by using the camera calibration results and the pose of robot. Then VoxelGrid filtering and moving least squares filtering are performed on the reconstructed model to smooth the error caused by camera and robot. The FPFH of point cloud is used to calculate the entropy map, and the weld seam region is extracted by threshold segmentation. Finally, an iterative algorithm for weld point extraction based on entropy is proposed. Through experimental verification, the algorithm can extract the weld points of the actual intersecting pipelines and obtain the real position of the weld points in the robot base coordinate frame, which has great application value in robot automatic welding area.

▶ ThurA01-5 14:50–15:10
PD-type Distributed ILC Protocol of Consensus for Nonlinear Multi-agent System with Fuzzy Topology Structure

Li, Yueying — Gaungxi Univ. of Sci. & Tech.
Dai, Xisheng — Guangxi Univ. of Sci. & Tech.,

This paper deals with the exact consensus problem of a class of second-order nonlinear multi-agent systems (MASs) with imprecise communication graph, a PD-type distributed iterative learning control protocol is constructed by modeling the imprecise topology as a T-S fuzzy graph. It is guaranteed that all followers can reach the state of the leader at the finite time interval. Based on the graph theory, a sufficient condition of exact consensus over the finite-time interval for the MAS is given by the compressing mapping framework. The convergence can be achieved with the existence of the control gain matrices. Finally, a numerical example is given to illustrate the effectiveness of the theorems.

▶ ThurA01-6 15:10–15:30
Direct and Indirect Technique Routes of Convergence Analysis for Discrete-time Iterative Learning Control

Liu, Jian — Xidian Univ.
Jia, Changqing — Xidian Univ.

This note is concerned with the direct and indirect technique routes of convergence analysis for discrete-time iterative learning control. It is first illustrated that the direct and indirect technique routes of convergence analysis for iterative learning control do not cause any contradiction. Then, it is shown that in the case the input-output coupling matrix is full-row rank, with resort to the input transform technique, we can use the indirect technique route to obtain the convergence of the output sequence. Finally, it is shown that in the case the input-output coupling matrix is full-column rank, we can directly analyze the convergence of the output sequence with resort to output transform technique.

ThurA02 13:30–15:30 Room 3
Invited Session: Control and Learning in Human-Robot Interaction Systems

Organizer: Yang, Yong — Xihua Univ.
Organizer: Xing, Xueyan — Univ. of Sussex
Organizer: Li, Yanan — Univ. of Sussex
Chair: Yang, Yong — Xihua Univ.
Co-Chair: Xing, Xueyan — Univ. of Sussex

▶ ThurA02-1 13:30–13:50
Position Constraints Adaptive Iterative Learning Control of Exoskeleton for the Preliminary Stage of Rehabilitation

Jin, Shuping — XiHua Univ.
Yang, Yong — Xihua Univ.
Dong, Xiucheng — Xihua Univ.
Liu, Xia — Xihua Univ.
Xia, Peng — Xihua Univ.

In this paper, the trajectory tracking control problem of an exoskeleton using in the preliminary stage of rehabilitation is addressed via adaptive iterative learning control. The disturbances are handled by radial basis function neural networks. A Lyapunov-like barrier composite energy function is utilized to ensure that position constraints are satisfied. With the help of the proposed control method, the exoskeleton leg can

achieve good tracking performance without violating output constraints. Convergence of system tracking errors is demonstrated by mathematical method and performance of the proposed controller is illustrated by numerical simulations.

▶ ThurA02-2 13:50–14:10
Control of Robotic Teleoperation System with Time Delay Based on Force Estimation

Sheng, Hao	Xihua Univ.
Liu, Xia	Xihua Univ.
Chen, Shini	Xihua Univ.
Jiang, Wenbo	Xihua Univ.
Guo, Yi	Xihua Univ.

For nonlinear teleoperation system with time delay, a control scheme based on force estimation is proposed. Since the force signals in teleoperation system are difficult to measure, a force estimation algorithm is designed to estimate the force signals. Using the estimated force signals and time delayed position error signals, two backstepping controllers are designed for teleoperation system. The performance of position tracking and force reflection of the system is analyzed, and the effectiveness of the proposed method is verified by simulations. The results show that the proposed control method can accurately estimate the force signals, and improve the performance of position tracking and force reflection while maintaining the stabilization of the robotic system.

▶ ThurA02-3 14:10–14:30
Robust ILC Approach for 2-D Linear Time-varying Continuous-discrete Systems

Wan, Kai	Huizhou Univ.
Wei, Xiao-Hui	School of Electronic Information & Electrical Engineering
Long, Dafeng	Huizhou Univ.
Xu, Qing-Yuan	Guangdong Polytechnic Normal Univ.

This paper first discusses the robust iterative learning control (ILC) problem on 2-D linear time-varying continuous-discrete systems with iteration-dependent boundary states. A continuous-discrete ILC law is proposed to ensure the ultimate tracking error converging to a bounded range. The upper bound of its is proportional to the boundedness parameter on iteration-dependent boundary states. In particular, while these iteration-dependent uncertainties are disappear, the ILC tracking error converges to zero. Finally, an illustrative test can be provided to illustrate the effectiveness of the proposed ILC law.

▶ ThurA02-4 14:30–14:50
Neural Networks Iterative Learning Impedance Control of Lower Limb Exoskeleton for the Later Stage of Rehabilitation

Xia, Peng	Xihua Univ.
Yang, Yong	Xihua Univ.
Jin, Shuping	XiHua Univ.
Liu, Xia	Xihua Univ.
Dong, Xiucheng	Xihua Univ.

In the later stage of lower limb rehabilitation training, impedance control is used to realize human-machine force interaction. An expected impedance model-based iterative learning controller is proposed in this paper. Iterative learning control is used to realize the target impedance model, which not only meets the repeatability of rehabilitation training, but also ensures the transient performance of lower limb rehabilitation exoskeleton. In order to solve the model uncertainty, neural networks (NN) is used to estimate the unknown dynamics of the exoskeleton. Simulation results further verify the effectiveness of the proposed control scheme.

▶ ThurA02-5 14:50–15:10
Iterative Learning Model Predictive Control for Lateral Control of Autonomous Vehicles

Chen, Yanfang	Sun Yat-sen Univ.
Li, Xuefang	National Univ. of Singapore

In this work, a novel iterative learning model predictive control method is proposed for lateral tracking control of autonomous vehicles. It endows the traditional model predictive controller with the ability of learning from previous experiences. In contrast to the existent iterative learning controllers that mainly concern the control performance in the iteration domain, the proposed control algorithm also takes the dynamical variations of the controlled system along the time axis to expedite the learning speed while ensuring the driving safety. In order to further enhance the robustness of the vehicle under uncertain driving environments, a control-affine feedforward neural network is incorporated to the proposed controller to deal with the system uncertainties and external disturbances. The convergence of the proposed control scheme is rigorously analyzed, and a numerical simulation is illustrated to verify the effectiveness of the proposed method.

▶ ThurA02-6 15:10–15:30
Optimal Second-Order Integral Sliding Mode Control for Underactuated Robotic System

Hu, Pan	Xihua Univ.
Liu, Xia	Xihua Univ.
Jiang, Wenbo	Xihua Univ.
Guo, Yi	Xihua Univ.

An optimal second-order integral sliding mode control (OSISMC) strategy is proposed for the stabilization control of underactuated robotic system. The proposed control strategy consists of an optimal control law and a second-order integral sliding mode (SISM) control law. The optimal control law is designed for the nominal system by the state-dependent Riccati equation (SDRE), making the system reach the optimal performance. Then, the optimal control law is introduced into the integral sliding mode surface, ensuring the robustness to the disturbance. In order to weaken the chattering, a SISM sliding surface is further designed and the OSISMC is obtained. The stabilization of the system is proved by Lyapunov theory. The simulation shows that the proposed OSISMC can improve the control performance and reduce the chattering.

ThurA03 13:30–15:30 Room 4
Regular Session: Data-driven Fault Diagnosis and Health Maintenance (I)

Chair: He, Yan-Lin Beijing Univ. of Chemical Tech.
Co-Chair: Xiong, Zhihua Tsinghua Univ.

▶ ThurA03-1 13:30–13:50
Operating Condition Identification of Complete Wind Turbine Using DBN and Improved DDPG-SOM

Wang, Zheng	Shanghai Jiao Tong Univ.
Chu, Xuening	Shanghai Jiao Tong Univ.

Although there have been a lot of researches on identifying the condition of components in wind turbine, such as blade, gearbox, bearings, etc., maintenance immediately after some component faults is not an optimal choice in practical use, since it leads to high-frequency downtime and large unnecessary cost. Therefore, the condition identification of complete wind turbine is required. In this paper, we propose a novel method based on data-driven techniques and information fusion model. Firstly, a DBN is used for capturing information about the condition of components in wind turbine. Then, a new information fusion model is presented for integrating the information about conditions of components based on an improved DDPG by incorporating a random module and SOM. Based on the output of the improved DDPG-SOM, a status index is calculated representing the condition of the whole machine. A case study based on real SCADA data is conducted to show the effectiveness and superiority of the proposed method.

▶ ThurA03-2 13:50–14:10
Multiple Recurrent Neural Networks Based Fault Diagnosis Model for Multi-mode Process

Wan, Chuan	Tsinghua Univ.
Zhang, Tongshuai	Tsinghua Univ.
Yang, Xiaojun	Tsinghua Univ.
Xiong, Zhihua	Tsinghua Univ.

The process operation of industry units generally has multiple modes, and the previous methods of fault diagnosis often need to first divide the data and then determine the specific mode situation. A multi-mode fault diagnosis model is proposed by composing of multiple recurrent neural networks (MRNN) in parallel, in which only one model is built for the complex modes without identifying mode information in advance. Parallel RNN modules are combined appropriately into the model to judge whether the current state of process operation is faulty from different perspectives, so as to achieve the similar effect of modeling a class of working modes for each module. Several fault prediction and training strategies are also studied for this model and the suitable strategy is proposed. The simulation data of the multi-mode process are generated through the Tennessee Eastman process to verify the effect of the proposed model.

▶ ThurA03-3 14:10–14:30
Knowledge Graph for Fault Diagnosis of Mechanical System

Chen, Hao — State Key Laboratory of Internet of Things for Smart City & Department of Electromechanical Engineering, Univ. of Macau
Wang, Xian-Bo — State Key Laboratory of Internet of Things for Smart City & Department of Electromechanical Engineering, Univ. of Macau
Yang, Zhi-Xin — Univ. of Macau

Knowledge graphs have been recognized as a useful technique for representing knowledge as a labeled directed graph. A novel method for fault diagnosis is proposed in which a customized knowledge graph model is built for rotating machinery fault diagnosis. The proposed specialized knowledge graph is a double-layer structure with a data layer and a pattern layer for data collecting and defect pattern recognition. The creation, update, and inference methods of FDKG are proposed in this study. The proposed update method ensures that the FDKG collects information comprehensively while filtering out effective features for inference diagnosis.Experimented result shows that the FDKG can integrate multiple features performe better than existing classification methods.

▶ ThurA03-4 14:30–14:50

Novel ARMF Integrated with Improved LSDA and Its Application in Fault Diagnosis

Zhu, Qunxiong — Beijing Univ. of Chemical Tech.
Zhang, Ning — Beijing Univ. of Chemical Tech.
He, Yan-Lin — Beijing Univ. of Chemical Tech.
Xu, Yuan — BEIJING Univ. OF CHEMICAL Tech.

The industrial process is developing to be intelligent and complex, thus the process data presents high dimension, nonlinearity and highly coupled features. Facing these features, this paper proposes a signal pattern-matching fault diagnosis method based on the adaptive rank-order morphological filter (ARMF) integrated with improved locality sensitive discriminant analysis (LSDA) named ILSDA-ARMF. This proposed methodology first fully extracts the variable features related to the fault using the improved LSDA; then the data after dimensionality reduction (DR) is used for signal pattern matching by using ARMF to achieve fault classification. The main advantage of the improved LSDA is that the Mahalanobis distance considers the correlation between samples and their nearest neighbor points. Meanwhile, the Tennessee Eastman (TE) chemical process is experimented with to verify the performance of the proposed ILSDA-ARMF. The simulation results show that the method proposed in this paper achieves more satisfactory results compared with other related methods.

▶ ThurA03-5 14:50–15:10

Control Performance Monitoring of RtR Controllers Based on Improved KL Divergence in Semiconductor Manufacturing Processes

Ling, Dan — Zhengzhou Univ. of Light Industry
Li, Chaosong — Zhengzhou Univ. of Light Industry
Lei, Ting — Zhengzhou Univ. of Light Industry
Wang, Yan — Zhengzhou Univ. of Light Industry
Guo, Danlei — Zhengzhou Univ. of Light Industry

Exponential weighted moving average (EWMA) run-to-run (RtR) controller is a widely used controller in semiconductor manufacturing process. Machine aging, model-plant mismatch and other factors lead to system performance degradation of EWMA RtR control system, wafer yield reduction, and even the safety of the manufacturing process degradation. A performance monitoring method for EWMA RtR control system is proposed based on improved KL divergence. First, a novel control performance index (CPI) is constructed based on improved KL divergence only requiring routine operation data. Then, the control limit of the proposed CPI is obtained by kernel density estimation (KDE) method. Next, the control performance online monitoring method is provided to monitor the performance of EWMA RtR control system. Finally, numerical simulations of chemical mechanical polishing (CMP) process are given to illustrate the efficiency of the proposed method.

▶ ThurA03-6 15:10–15:30

Bearing Fault Diagnosis Based on Multiple Feature Transfer Learning Network

Qiao, Huanzhang — Shandong Univ.
Liu, Lida — Shandong Raone Tech. Co., LTD
Tian, Xincheng — Shandong Univ.
Liu, Yan — Shandong Univ.

The intelligent fault diagnosis methods have gained great success, they usually depend on large amounts of labeled data. Unfortunately, it is a realistic problem to collected massive labeled data in actual industrial scene. In addition, even labeled data is easy to collect, the methods trained by these labeled data may not be able to classify unlabeled data obtained under different working states. Inspired by transfer learning, in the paper we propose a deep learning-based fault diagnosis method named multiple feature transfer learning network (MFTLN) to resolve the data distribution difference due to changed working conditions. MFTLN employee multiple extractors to get domain-invariant features and align source domain and target domain by maximum mean discrepancy (MMD) metric. We performed six bearing fault diagnosis transfer learning experiments to verify the superiority of the proposed method, the experimental results indicated that the recognition accuracy of the proposed method is obviously higher than those of the other 5 popular domain adaptive fault diagnosis methods when the target domain data is unlabeled.

ThurA04 13:30–15:30 Room 5

Regular Session: Statistical Learning and Machine Learning in Automation Field (I)

Chair: Wang, Youqing -
Co-Chair: Tian, Xincheng Shandong Univ.

▶ ThurA04-1 13:30–13:50

Vehicle Tracking Method Based on Attention-YOLOv5 and Optimized DeepSort Models

Li, Zhuang — Shandong Univ.
Tian, Xincheng — Shandong Univ.
Liu, Yan — Shandong Univ.
Shi, Xiaorui — SINOTRUK Jinan Power Co.,Ltd

Vehicle tracking plays a vital role in traffic management and autonomous driving. In order to further improve the accuracy of vehicle tracking, reduce the number of ID-Switch and enhance the anti-interference ability to the outside world, we propose a vehicle detection and tracking model based on Attention-YOLOv5 and optimized DeepSort. Firstly, YOLOv5 with attention mechanism was used as the front-end target detector, that is, add CBAM and ECA attention mechanisms to the backbone network of the benchmark YOLOv5 separately to improve the feature extraction ability. Then use the transfer learning idea to train it on the BDD dataset, it is concluded that ECA-YOLOv5 has the highest detection accuracy. Further we optimize the DeepSort algorithm, in order to overcome the disadvantages of the pre-training model not targeting traffic vehicles, we improve the re-recognition network structure and optimize the VeRi re-identification dataset, next perform re-identification pre-training on the Improved-VeRi dataset based on transfer learning. In order to make the vehicle features evenly distributed around the center of the class and improve feature resolution, a loss function L_(vehicle_CL) combining the Softmax loss function and Center loss function is proposed. In the experimental part, collecting some highway traffic videos of different scenes. At first, conduct visual analysis, then perform ablation experiments, and evaluate by using MOTA, MOTP and ID-Switch. Compared with the benchmark algorithm, the tracking performance is significantly improved.

▶ ThurA04-2 13:50–14:10

An Accurate Feature Extraction Cluster Algorithm for Damage Detection Based on Thermography

Zhang, Bo — Univ. of Electronic Sci. & Tech.
Yin, Chun — Univ. of Electronic Sci. & Tech. of China
Huang, Xuegang — China Aerodynamics Research & Development

Advanced metal material has been widely used in aerospace equipment components as the high performance materials, however, the harsh environment and low damage tolerance add the risk of the damage of materials. Condition detection is therefore required to guarantee the safety of the device. In this paper, in order to accomplish accurate extraction and damage visualization, an accurate damage cluster visualization algorithm through thermography is proposed. The presented method includes two parts: variable interval search and accurate cluster. The variable interval search combined with the accurate cluster can extract the feature precisely and reduce the redundant calculation in the accurate defect visualization. Experimental results prove the efficiency and benefits of the proposed algorithm in accurate damage cluster visualization.

▶ ThurA04-3 14:10–14:30

Ballast Resistance Estimation Method Based on One Dimensional Convolutional Neural Network

Xie, Yuxin — Beijing JiaoTong Univ.
Yang, Shiwu — Beijing Jiaotong Univ.
Liu, Chang — Beijing Jiaotong Univ.

Wang, Conghui Beijing Jiaotong Univ.

Ballast resistance, as the basic transmission parameter of track circuits, is susceptible to various factors such as climate, material, environment, etc., presenting the characteristics of dynamic changes, even causing the main factor of affecting stable operation. Jointless track circuits are the mainstream apparatus widely used in China's high-speed railways, whose channels are uneven due to compensation capacitors and tuning units. Coupled with the train operation restrictions, it is difficult to achieve dynamic measurement result of ballast resistance. Under this background, considering the strong data processing ability of the one-dimensional convolution network, this paper proposes a ballast resistance estimated method by building a corresponding algorithmic model. Firstly, based on the theory of the four-terminal network and uniform transmission line, the equivalent model of track circuit under the shunting state is established. The key point is to obtain the sequence of the cab signal receiving voltage by changing the ballast resistance and transmitting level. Then, the voltage sequence plays the part of input into the one-dimensional convolutional network as a data set to train the ballast resistance estimated model. After training the network and selecting the best network parameters, the accuracies of the training set and the validation set are approach 90% and 95%, respectively, and that of the test set reaches 90.2%. The result shows that the established model has a relatively high fitting accuracy , and its application helps save manpower and costs, improving efficiency.

▶ ThurA04-4 14:30–14:50

EEG Motor Imagery Decoding Based on Common Spatial Pattern and Ensemble Learning at the Source Space

Huang, Jiazhang Chongqing Univ. of Posts & Telecommunications
Liu, Ke Chongqing Unversity of Posts & Telecommunications
Deng, Xin Chongqing Univ. of Posts & Telecommunications

Due to the volume conduct effect, the spatial resolution of electroencephalography (EEG) is low, leading to the limited motor imagery (MI) decoding accuracy based on the scalp EEG signals. In this work, we propose a new MI decoding method based on the EEG source imaging (ESI). Specifically, we first divide the cortical motor areas into several regions of interest (ROIs) using the multi-source preregistration method. Subsequently, we employ the ESI algorithms to reconstruct the cortical sources within the motor areas, obtaining much higher spatial resolution information for MI decoding. The common spatial pattern (CSP) is then applied to each ROI. Using cross-validation, twenty ROIs contributing to the MI decoding the most are selected. Finally, the decoding decision is obtained based on the ensemble decision of the selected ROIs. Experiments results based on two public datasets show the superior MI decoding performance in the source space than that in the sensor space.

▶ ThurA04-5 14:50–15:10

Fault Diagnosis of Rolling Bearing Based on Improved Convolutional Neural Network

Lin, Zichen Huzhou Univ.
Wang, Peiliang Huzhou Univ.
Chen, Yangde Huzhou Univ.
Sun, Chenhao Huzhou Univ.

Fault diagnosis of rolling bearing is the key to condition monitoring and prediction maintenance of rotating machinery. In order to solve the problem that traditional fault diagnosis methods need to extract fault features manually and convolutional neural network is easy to produce gradient disappearance, a fault diagnosis algorithm based on improved One-Dimensional Convolutional Neural Network (1D-CNN) and Residual Network (Resnet) is proposed. Firstly, one-dimensional convolution layer and pooling layer are used to complete the extraction and compression of data fault features. Then, the improved residual network is added to avoid network degradation and data internal distribution inequality in the training model. The Global average pooling is also used to replace the full join operation to reduce the parameters of the training model. And through the Dropout technology, the neurons in the structure are randomly deactivated to prevent complex cooperative responses to the training data. Finally, the Softmax classifier is used for fault classification, and the dynamic learning rate is used to adjust the convergence speed of the model to prevent the occurrence of local optimum. The experimental results show that the method has good fault diagnosis ability.

▶ ThurA04-6 15:10–15:30

Semi-Distributed Intermediate Observer for Heterogeneous Multi-Agent Systems with Homologous Fault

Sheng, Jie Shandong Univ. of Sci. & Tech.
Wang, Youqing -

In this study, the homologous fault estimation problem is considered for continuous time multi-agent systems with actuator faults. A semi-distributed intermediate observer is proposed to estimate the system state and fault simultaneously. The observer does not require the system to satisfy the strict positive real condition and the observer matching condition. The design of the observer not only uses neighbors' information but also optimizes the utilization efficiency of neighbors' information, which is beneficial to the performance of the observer and reduces the communication burden. When the communication topology is a directed graph, a sufficient condition is given to ensure that the state and fault estimation errors are uniformly ultimately bounded. The linear matrix inequality technique is used to calculate the observer parameter. Finally, simulation results verify the effectiveness of the proposed method.

ThurA05 13:30–15:30 Room 6

Regular Session: Model-free Adaptive Control

Chair: Yao, Wen-Long Qingdao Univ. of Sci. & Tech.
Co-Chair: Cao, Rongmin Beijing Information Sci. & Tech. of Univ.

▶ ThurA05-1 13:30–13:50

Maximum Power Point Tracking of Merchant Marine Photovoltaic System Based on MFALC

Zhuang, Yongbo Qingdao Port International Co., Ltd
Pei, Chunbo Qingdao Univ. of Sci. & Tech.
Yao, Wen-Long Qingdao Univ. of Sci. & Tech.
Chi, Ronghu Qingdao Univ. of Sci. & Tech.
Wen, Hongjie Qingdao Port International Co., Ltd
Guo, Yiyun Ocean Univ. of China

To optimize photovoltaic (PV) power generation efficiency and the stability of output power, the paper presents an MPPT (Maximum Power Point Tracking) technology for PV system of merchant marines. For the unstable weather, ship roll and the sea salt crystallization on solar panels under complex sea condition disturbance, the MPPT controller is difficult to design according to the accurate PV panels model. We propose a boost converter control strategy based on MFALC (Model Free Adaptive-learning Control). Firstly, a general discrete non-linear system is established according to the data of PV panels output and inputs; Secondly, a data model based on compact form dynamic linearization is carried out to design the MFALC controller; Thirdly, the pseudo partial derivative estimation algorithm is given. The proposed strategy effectively reduces the power oscillation of ship PV system and achieve MPPT rapidly under different operating conditions. The simulation results verify the effectiveness and advantages of the proposed control strategy compared with the perturbation and observation method.

▶ ThurA05-2 13:50–14:10

Multiple Input Multiple Output Model-free Adaptive Iterative Learning Control of Two-dimensional Linear Motor Based on Neural Network

Zheng, Xinxin Beijing Univ. of Information Tech.
Cao, Rongmin Beijing Information Sci. & Tech. of Univ.
Hou, Zhongsheng Beijing Jiaotong Univ.

The two-dimensional linear motor control system has the characteristics of nonlinear, multi-variable and strong coupling. In the actual operation process, it is affected by load disturbance, mechanical delay, friction resistance and other factors, and the dynamics model is difficult to accurately obtain, so its tracking control is extremely hard. Radial Basis Function (RBF) based neural network has the advantage of arbitrary approximation to nonlinear function and Model Free Adaptive Iterative Learning Control (MFAILC) does not depend on the characteristics of accurate mathematical model of the controlled system and the rule of sequential learning. A multi-input multi-output model-free adaptive iterative learning control(MIMO-MFAILC) strategy based on RBF neural network is proposed. RBF neural network is used to learn pseudo partial derivative (PPD) online in model-free adaptive iterative learning control. As feedforward compensation, the iterative learning control can overcome external interference, compensate system nonlinearity, and complement feedforward and feedback advantages, so as to realize the precision compensation of expected tracking and further improve position tracking accuracy. Finally, the accuracy and effectiveness of the proposed strategy are verified experimentally by combining RT-SIM simulation platform with 2d linear motor control system under no-load and load conditions.

▶ ThurA05-3 14:10–14:30

Inverse-Free Tracking Control of Continuum Robots with Unknown Models Based on Gradient Neural Networks

Yu, Peng Sun Yat-sen Univ.
Tan, Ning Sun Yat-sen Univ.
Zhang, Mao SUN YAT-SEN Univ.
Ni, Fenglei Harbin Inst. of Tech.

The inherent dexterity and compliance of continuum robots have endeared them to numerous researchers. However, the control of continuum robots remains a complicated problem worth studying as a result of their intricate structures. In this work, we present a scheme based on gradient neural networks (GNN) for the control of continuum robots with unknown models. The proposed scheme is composed of two GNN models, one of which is employed for the solution of inverse kinematics problem, and the other is used to estimate the Jacobian matrix of continuum robots. This design allows us to rely only on user-defined input and sensory output to achieve the tracking control of continuum robots, without knowing their models and internal structures. The convergence of the proposed scheme is proven by theoretical analysis. Finally, the feasibility and merits of the proposed scheme are revealed by simulation studies, including performance analysis and comparisons.

▶ ThurA05-4 14:30–14:50

An Improved Feedback-feedforward Model-free Adaptive Iterative Learning Control with High-order Estimation

Ji, Honghai North China Univ. of Tech.
You, Yue North China Univ. of Tech.
Liu, Shida Beijing Jiaotong Univ.
Fan, Lingling Beijing Information Sci. & Tech. Univ.
Hou, Zhongsheng Beijing Jiaotong Univ.

In this paper, an improved feedback-feedforward model-free adaptive iterative learning control with high-order estimation (FF-HOE-MFAILC) is proposed for the discrete-time nonlinear system. A novel pseudo-partial derivatives (PPD) estimation algorithm is derived based on the high-order optimization input criterion function with a proof derivation. Then, the model-free adaptive control with PPD high-order estimation is used as the feedback control term. Moreover, to improve the rapidity and accuracy of convergence, a P-type iterative learning control is employed into the proposed improved MFAC as the feedforward control term. This algorithm is essential a data-driven control method involved the repetitive iterative learning ability for nonlinear system. Numerical simulations are conducted to demonstrate the effectiveness of the proposed FF-HOE-MFAILC. Compared with the existing improved-MFAC (i-MFAC) and MFAC-based feedback-feedforward ILC (MFAC+ILC), our FF-HOE-MFAILC is proven by some comparative analyses that, the convergent speed is increased and the tracking error is decreased significantly.

▶ ThurA05-5 14:50–15:10

Event-Triggered Model-Free Adaptive Predictive Control for Nonlinear NCSs Subject to Data Dropout Compensation and Application in PMSM Control System

Wang, Yu Qingdao Univ.
Hou, Zhongsheng Beijing Jiaotong Univ.

For a class of nonlinear networked control systems (NCSs) subject to data dropouts, this paper studies the problem of the event-triggered model-free adaptive predictive control (ET-MFAPC), and a new ET-MFAPC scheme with data dropouts compensation is proposed to track the desired output. The main advantage of the proposed control scheme is that it has the prediction function, its the event triggering conditions of this scheme are complex, which reduces the calculation requirements, and pseudo partial derivative estimation algorithm is a real-time online estimation algorithm. In addition, the uniform boundedness of the tracking error of the closed-loop system in the mean square sense is also discussed. Finally, it is applied to PMSM speed control system to verify the effectiveness of the proposed ET-MFAPC algorithm.

▶ ThurA05-6 15:10–15:30

Adaptive Nonlinear Variable Gain PID Controller for 3D Obstacle Avoidance of Delivery Drone

Zhang, Yanhui Zhejiang Univ.
Chen, Weifang Zhejiang Univ.

In this paper, the obstacle avoidance trajectory control (OATC) problem is investigated for a quadrotor to achieve express deliveries. A nonlinear variable gains proportional-integral-derivative (NLVG-PID) controller is presented to adapt to large-angle maneuver and weight change of express package in the mission of drone delivery. The NLVG-PID control unit consists of a nonlinear variable gain function and a boundary extremum seeking (ES) algorithm to decrease the percentage peak overshoot and settling times. In addition, rigorous Hurwitz-based stability proof is provided to ensure the convergence of tracking errors when the initial states belong to a compact set. Finally, numerical simulations of quadrotors are performed to validate the effectiveness of the proposed control scheme via three types of collision-free trajectories.

ThurA06 13:30–15:35 Room 7

Award Session: Best Paper

Chair: SUN, Mingxuan Zhejiang Univ. of Tech.

▶ ThurA06-1 13:30–13:55

Moving-target-enclosing Control for Multiple Nonholonomic Mobile Agents with Bearing Measurements

Ju, Shuang Beijing Univ. of Chemical Tech.
Wang, Jing North China Univ. of Tech., China
Dou, Liya Beijing Univ. of Chemical Tech.

In the note, a target enclosing control problem of a moving target for multiple nonholonomic mobile agents is investigated by bearing measurements. A virtual auxiliary system is first introduced to assist in generating a desired reference trajectory of each agent. Simultaneously, by using the bearing measurements, an observer is designed to localize the target. Then, based on the virtual auxiliary system and the observer, a dynamic control law is proposed to let the agents globally asymptotically converge to a circular orbit centered at the moving target and maintain a desired distribution on the orbit. Finally, simulation results verify the effectiveness of the proposed approach.

▶ ThurA06-2 13:55–14:20

Fast Depth Estimation of Object via Neural Network Perspective Projection

Yu, Han Chinese Acad. of Sci.
Chen, Yaran Chinese Acad. of Sci.
Li, Haoran Univ. of Chinese Acad. of Sci.
Ma, Mingjun Chinese Acad. of Sci.
Zhao, Dong-Bin Inst. of Automation

In autonomous driving and mobile robotic systems, obtaining the depths of objects in real-time is crucial. The current network-based methods usually design complex network to achieve 3D object detection or monocular depth estimation for the whole image, resulting in too slow to be applied to mobile robots. The perspective projection-based method can achieve real- time, which calculates the object depth based on the camera parameters, the object sizes in the world coordinates and in image coordinates. While it relies heavily on the accuracy of object size in images coordinates, and the size is usually obtained with errors through detector network. Combining the perspective projection-based methods and network-based methods, we propose a fast object depth estimation method by designing a neural network to learn perspective projection, called Fast-Depth-NPP: 1) Instead of considering the whole image, we only consider the local depth of the image; 2) Using local image patches as network inputs avoids measurement errors of object size with detector; 3) the use of global information is enhanced by incorporating position encoding. Our method is validated on the mobile robot public dataset Neurons Perception dataset, achieving excellent results and meeting the real-time requirements.

▶ ThurA06-3 14:20–14:45

Extended Iterative Learning Control for Inconsistent Tracking Problems with Random Dropouts

Zhang, Zeyi Renmin Univ. of China
Jiang, Hao Renmin Univ. of China
Shen, Dong Renmin Univ. of China

For the inconsistent tracking problem where the given reference cannot be precisely generated by the system dynamics, it is generally required to achieve the best approximation to the reference trajectory. In this study, an extended iterative learning control algorithm is proposed to address this problem for linear time-varying systems under data dropouts. The errors in the update law are modified utilizing the reference trajectory and the Bernoulli probability model of data dropout. The input sequence is proven convergent to the desired input, which produces the closest output to the desired reference in the least square sense. Numerical simulations are provided to verify the theoretical results.

▶ ThurA06-4 14:45–15:10

Finite-iteration Adaptive ILC for Automatic Operation of High-speed Trains

Yu, Qiongxia Henan Polytechnic Univ.
Hou, Yiteng Henan Polytechnic Univ.
Tian, Fengchen Henan Polytechnic Univ.

Bu, Xuhui Henan Polytechnic Univ.

Iterative learning control (ILC) is a typical method for automatic high-speed train (HST) control. However, the existing ILC methods require that the operation/iteration number of the HST must approach infinity so as to guarantee perfect tracking. This requirement is unrealistic for practical automatic train control. In this paper, a new finite-iteration adaptive ILC (FIAILC) method is proposed and a new framework of composite energy function-based finite-iteration convergence theory is given for the first time. The proposed FIAILC can make the tracking error not only converge to zero as the iteration number go to infinity, but converge to an arbitrarily predefined tracking control precision after a finite number of iterations. This finite iteration number can be obtained theoretically according to the predefined tracking control precision as well as the tunable gain and initial values of the proposed controller. The result is further extended to the HST operation system with speed constraint and a constrained FIAILC is designed accordingly. Moreover, three simulation cases on a practical train operation system similar to China Railway High-speed (CRH)-3 HST are given to show the effectiveness of the proposed FIAILCs.

▶ ThurA06-5 15:10–15:35

Multi-Player Robust Control of Stackelberg Games via Adaptive Dynamic Programming

Zhang, Yongwei School of Automation
Zhang, Shunchao Guangdong Univ. of Tech.
Zhao, Bo Beijing Normal Univ.
Liu, Derong CASIA

In this paper, the hierarchical optimization problem of multi-player systems with matched uncertainties is investigated via adaptive dynamic programming. In the hierarchical optimization problem, there exist one leader and multiple followers, the leader chooses a policy in advance based on the actions of the followers, and the followers make optimal responses to the leader's policy. The optimal policies of the leader and the followers form the Stackelberg equilibrium. By designing appropriate value functions for the leader and the followers, the hierarchical optimization problem is formulated as a Stackelberg game and the robust stabilization problem is transformed into an optimal regulation problem. Moreover, the critic-only structure is established to obtain the approximate Stackelberg equilibrium. Theoretical analysis shows that the developed ADP-based robust control guarantees the closed-loop system to be asymptotically stable. Finally, simulation example is adopted to verify the effectiveness of the present scheme.

ThurB01 15:40–17:40 Room 1

Regular Session: Data Driven Control (I)

Chair: You, Keyou Tsinghua Univ.
Co-Chair: Zheng, Dongdong Beijing Inst. of Tech.

▶ ThurB01-1 15:40–16:00

Controller Design of Linear Systems via Policy Optimization Methods

Zhao, Feiran Tsinghua Univ.
You, Keyou Tsinghua Univ.

We review a recently developed data-driven control framework without using system identification, named Policy Optimization (PO), an essential approach of reinforcement learning, and briefly discuss some control design problems solved by PO methods including $mathcal H_{infty}$ control, system stabilization, etc.

▶ ThurB01-2 16:00–16:20

How Much Data is Sufficient for Linear System Analysis without Explicit Model?

Kang, Shubo Tsinghua Univ.
You, Keyou Tsinghua Univ.

Data-driven analysis is the basic procedure for data-driven control. As data may be costly to obtain in practice, it will be meaningful to find how much data at least is sufficient for identifying a certain property. In this work, we answer the question in the case of sectional data, and prove that a minimum subspace of the state-control inputs can be find. The result for fundamental properties like stabilizability and controllability is given, which implies that model identification is almost needed for identifying these two properties. Moreover, the conditions for identifying properties that have only linear constraints are shown.

▶ ThurB01-3 16:20–16:40

Unknown System Dynamics Estimator for Motion Control of Robotic Manipulator with Flexible Joints

Li, Yantian Kunming Univ. of Sci. & Tech.
Huang, Yingbo Kunming Univ. of Sci. & Tech.
Na, Jing Kunming Univ. of Sci. & Tech.
Wang, Xian Kunming Univ. of Sci. & Tech.
Gao, Guanbin Kunming Univ. of Sci. & Tech.

In this paper, an unknown system dynamic estimator (USDE) with only partial model information is proposed to design a feedback controller for a flexible joint manipulator. In this framework, both the unmodeled dynamics of the system and the effect of flexible joints are estimated and a diagonal matrix is constructed to reduce the computational burden in multi-degree-of-freedom robot control. Furthermore, the USDE-based feedback controller is designed to guarantee the tracking performance. Theoretical analysis is studied in terms of the Lyapunov theory. Finally, comparative numerical simulation results are provided based on Baxter robotic system to demonstrate the feasibility and effectiveness of the proposed method.

▶ ThurB01-4 16:40–17:00

USDE-Based Approximation-Free Control for Robot System with Prescribed Performance

Zhang, Chao Beijing Inst. of Tech.
Ren, Xuemei Beijing Inst. of Tech.
Zheng, Dongdong Beijing Inst. of Tech.

This paper presents an unknown system dynamics estimator (USDE)-based approximation-free control strategy for robot system with unknown dynamics. A prescribed performance function and associated error conversion mechanism is employed to guarantee the transient and steady-state error of robot system. Moreover, the USDE is constructed by a first-order low-pass filter operation with only one turning parameter, and then introducing to approximation-free control design to compensate the modeling uncertainties and unknown dynamics to further improve the tracking performance and reduce the controller complexity. The stability of closed-loop system is proved by Lyapunov and initial value theory. Simulations are carried out to validate the effectiveness of the proposed scheme based on a SCARA robot.

▶ ThurB01-5 17:00–17:20

Data-driven Control of Event-triggered Linear Systems

Wang, Xin Beijing Inst. of Tech.
Sun, Jian Beijing Inst. of Tech.
Wang, Gang Beijing Inst. of Tech.

The present paper considers the data-driven control of unknown linear time-invariant discrete-time systems under an event-triggering transmission scheme. To this end, we begin by presenting a dynamic event-triggering scheme (ETS) based on periodic sampling, and a discrete-time looped-functional (DLF) approach, through which a model-based stability condition is derived. Combining the model-based condition with a recent data-based system representation, a data-driven stability criterion in the form of linear matrix inequalities (LMIs) is established, which offers a way of co-designing the ETS matrix and the controller using pre-collected noisy input-state data. Finally, numerical simulations showcase the efficacy of ETS in reducing data transmissions as well as of the proposed co-design methods.

▶ ThurB01-6 17:20–17:40

Data-driven ESO-based LOS Guidance Law for Path Following of Unmanned Surface Vehicles with Sideslip Compensation

Zhang, Wenjun Dalian Maritime Univ.
Wang, Fuqiang Dalian Maritime Univ.
Zhai, Lirong Liaoning Univ.

In this paper, aiming at the path tracking problem of under-actuated unmanned surface vehicles (USVs) with unknown sideslip angle, a line-of-sight (LOS) guidance method based on data-driven extended state observer(ESO) is proposed, which realizes the accurate estimation and compensation of the time-varying sideslip angle. Then, simulation results verify the effectiveness of the proposed method. Compared with the traditional LOS guidance, the proposed guidance method can effectively compensate the time-varying sideslip angle and improve the accuracy of the path following of the under-actuated USVs.

ThurB02 15:40–17:40 Room 3

Regular Session: Data-driven Control for Practical Complex Processes

Chair: Bu, Xuhui Henan Polytechnic Univ.
Co-Chair: Mi, Bo Chongqing Jiaotong Univ.

▶ ThurB02-1 15:40–16:00

Tracking Control of Two Virtually Coupled Trains via Prescribed Performance Control Method

Jia, Yuqi Southwest Jiaotong Univ.
Huang, Deqing Southwest Jiaotong Univ.

Li, Xuefang National Univ. of Singapore

As a new concept in railways, virtual coupling has been proven that could reduce the separation between two adjacent trains, and thus increase the railway capacity effectively. However, the shorter separation distance will lead to the stricter requirements for the tracking accuracy. The prescribed performance control method could restrict the convergence rate and the convergence range of the tracking error, thus could improve the tracking accuracy effectively. Based on this, a novel tracking control scheme for two virtually coupled trains under the framework of the prescribed performance control is developed in this paper. To deal with the system uncertainties, a fuzzy logic system is applied to approximate the unknown resistance. At last, the convergence of the proposed controller is proved by virtue of the Lyapunov stability theorem and its effectiveness is analyzed through numerical simulations.

▶ ThurB02-2 16:00–16:20

Model-free Adaptive Sliding Mode Control for Interconnected Power Systems under DoS Attacks

Chen, Zongyao Henan Polytechnic Univ.
Bu, Xuhui Henan Polytechnic Univ.
Guo, Jinli Henan Polytechnic Univ.

In this paper, a new model-free adaptive sliding mode load frequency control (LFC) scheme is designed for interconnected power systems, where modeling is difficult and suffers from load change disturbances and denial of service (DoS) attacks. The proposed algorithm only uses real-time I/O data of the power system to achieve a high control performance. Firstly, the dynamic linearization strategy is used to build a data-based model of the power system, and intermittent DoS attacks are modeled by limiting their duration and frequency. Secondly, the model-free adaptive sliding mode control (MFASMC) scheme is designed based on optimization theory and sliding mode reaching law, and its stability is analyzed. Finally, the three-area interconnected power system was selected to test the presented MFASMC scheme. Simulation data shows the effectiveness of the LFC algorithm in this paper.

▶ ThurB02-3 16:20–16:40

Performance Analysis of Optimal Relay Selection for Urban Vehicles Based on Max-min Strategy

Yi, Junjie North China Univ. of Tech.
Liu, Lei North China Univ. of Tech.

In this paper, a cooperative non-orthogonal multiple access (NOMA) vehicle communication system in urban scenarios is studied. Max-min optimal relay selection strategy is adopted to derive the closed-form expressions of channel capacity and interruption probability for the target vehicle users. In the simulation, the influence of relay number, road loss, power allocation and destination vehicle distance on the system is considered, and the proposed max-min optimal relay selection strategy is compared with three relay selection strategies, namely Max-SR, Max-RD and random relay. The results show that the proposed max-min optimal relay selection strategy achieves the better user performance of destination vehicle.

▶ ThurB02-4 16:40–17:00

A New IBE Scheme Based on Conjugate Search Problem

Deng, Zhaoyang Chongqing Jiaotong Univ.
Mi, Bo Chongqing Jiaotong Univ.
Huang, Darong Chongqing Jiaotong Univ.
Hao, Lingyi Chongqing Jiaotong Univ.

With the rapid development of Internet of Vehicles (IoV) technology, its security problem is attracting more and more attention. In this paper, an identity-based encryption scheme based on the conjugate search problem is proposed for the Internet of vehicles. In the scheme, the identity ID of the vehicle is directly used as the public key during communication, and the additional facilities for maintaining the identity certificate are no longer necessary. The scheme is based on the matrix over groupring, which can improve the efficiency of operations, and the scheme reduces the storage space by introducing the circulant matrix. Finally, the security reduction of the scheme to the Conjugate Search Problem based Diffie-Hellman assumption (CSP-DDH) under the random oracle model is proved, and the scheme is semantically secure under the Chosen Plaintext Attack.

▶ ThurB02-5 17:00–17:20

Research on Competition-reciprocity Network of State Owned Commercial Banks in Wuhan and Its Statistics Analysis

Liu, Jie Wuhan Textile Univ.

In recent years, the research on the layout and performance evaluation of urban financial services has been a hot and forward issue in the field of econometric research. With the rapid development of economy and technology, the strength of domestic large commercial banks has been constantly enhanced, which plays an important role in supporting and guaranteeing the development of local economy and the improvement of people's living standards. At the same time, the competition among commercial banks is becoming more and more fierce. Trying to find out the geographical distribution characteristics of the existing commercial banks in the core cities can not only help the urban financial function planning and management decision makers arrange the layout of existing banks to serve the real economy and the public life, but also improve the performance of commercial banks. Based on the complex network analysis and visualization analysis method, by using the geographic information data visualization technology, firstly, this paper analyzes the main factors that affect the distribution of outlets of state-owned commercial banks in Wuhan. Our results show that the distribution of outlets of state-owned commercial banks in Wuhan has a significant positive correlation with the output value of the tertiary industry and the number of permanent residents. It also has a significant negative correlation with the output value of the secondary industry. At the same time, by using data visualization method, we analyzed the geographical distribution characteristics of Wuhan state-owned commercial banks. Secondly, the network of competition reciprocity relationship among outlets was constructed. Finally, this paper gave a quantitative analysis of the digital characteristics of the competition reciprocity network among the existing state-owned commercial banks in Wuhan. Results of this paper can provide some valuable quantitative reference for the scientific decision-making practice of optimizing the layout of urban financial functional areas of state-owned commercial banks.

▶ ThurB02-6 17:20–17:40

Distance-based Formation Control of Holonomic Mobile Robot Multi-agent System in Finite Time

Lei, Qiao Lanzhou Jiaotong Univ.
Li, Zonggang Lanzhou Jiaotong Univ.

The distributed control of multi-robot system has a great potential in practical application, thus it has gained numerous attentaion. Among them, the formation control has become one of the main research contents. It mainly includes the form of formation, the maintenance and the transformation of formation. The position, orientation and velocity of neighbouring robots need to be obtained during the formation maintenance.In reference[1], the distance-based formation control has been studied, in which formation maintenance is achieved by obtaining the relative positions of adjacent robots in the local coordinate system through onboard sensors and controlling the distance between robots at the same time.Comparing with displacement-based and position-based formation control, distance-based formation control is more flexible, because it dose not need access to global information, in some environment where the GPS signal is weak orinexistence, the distance-based formation control has a very high application value. It can throw off some environmental constraints of the multi-robot system strictly and has higher practicability in a specific task. In reference[2], a distributed leader-follow formation control strategy for underactuated mobile robots has been studied, in which the desired distance between robots is given. In literature[3, 4], the author studied formation control of nonholonomic mobile robots, in which the relative positions between followers are given and formation control is finally realized. In reference[5], the author proposed a distance-based formation control in which the assumption of target formation was minimal and infinitesimally rigid. Although the asymptotic convergence of target formation was finally achieved,the assumption of distance between all robots was small enough to achieve local asymptotic convergence of target formation.Literature[6], in the framework of leader-follower the author studied a single integrator model of multi-agent system on the basis of the rigid graph theory, in which the goals of the multi-robot formation are minimally and infinitesimally rigid, formation control was achieved by the velocity estimator and formation controler in finite time. Different from the assumption in the previous article that only the relative distance between robots is given. For example, the relative positions between robots are not fixed,so the restriction conditions of formation control can be satisfied by adjusting the relative positions between robots.In reference[7], the author designed a velocity estimator of leader and a formation controller for each robot, but did not limit the orientation of the robots. In this paper, formation control of multiple robots based on distance in finite

time for nonholonomic mobile robots is studied on the basis of rigid graph theory, where the topology of formation is a minimally and infinitesimally rigid graph. Assume that at least two robots can obtain information about the leader's relative position, and at least one robot can obtain information about the leader's velocity. In order to achieve the goal of formation control, a distributed velocity estimator and a rigid formation controller are designed.

ThurB03 15:40–17:40 Room 4

Invited Session: ADRC: Design, Theory and Application

Organizer: Yang, Zhijun — Guangdong Univ. of Tech.
Organizer: Chen, Sen — Shaanxi Normal Univ.
Organizer: Zhao, Zhiliang — Shaanxi Normal Univ.
Chair: Yang, Zhijun — Guangdong Univ. of Tech.
Co-Chair: Qi, Guoyuan — Tiangong Univ.

▶ ThurB03-1 15:40–16:00

Fixed-time Switching Sliding Mode Control for Second-order Nonlinear Systems

Wei, Xinyi — Nankai Univ.
Wang, Fuyong — Nankai Univ.
Liu, Zhongxin — College of Artificial Intelligent, NanKai Univ.
Chen, Zengqiang — Nankai Univ.

This paper presents a novel fixed-time sliding mode controller for second-order nonlinear systems with matched disturbances. To satisfy the prerequisite of fixed-time stability and simplify the design, a new continuous switching sliding surface is proposed, which ensure that the state of system will reach the equilibrium point in a fixed time after reaching the sliding surface. Based on the feature of the surface, a simple sliding mode controller is designed by using exponential sliding mode variable so that the chattering phenomenon is effectively improved and the global fixed-time stability will be achieved. Simulation results show the excellent performance of the proposed controller.

▶ ThurB03-2 16:00–16:20

Cascade Sliding Mode Control of Four-sided Clamped Plate Based on Extended State Observer

Gu, Renjing — Yangzhou Univ.
Li, Shengquan — Yangzhou Univ.
Zhang, Luyao — Yangzhou Univ.
Zhang, Jie — Yangzhou Univ.
Li, Juan — Southeast Univ.

A cascade sliding mode control (CSMC) strategy based on an extended state observer (ESO) is proposed to solve the problems of model uncertainty and strong external disturbances of an all-clamped plate based on an inertial actuator in this paper. First, the mathematical model of the system structure is established. Second, the internal uncertainty and external disturbance of the system are defined as the total disturbance, and the corresponding extended state observer is established to estimate the total disturbance of the system. Then, the cascade sliding is designed in combination with the extended state observer. The whole controller uses the estimated value of the disturbance to compensate the influence of the disturbances, and realizes the suppression of the structural vibration. Finally, the proposed control strategy is proved to have satisfactory robustness and vibration suppression performance by real time hardware-in-the-loop experiments.

▶ ThurB03-3 16:20–16:40

A Composite Linear Active Disturbance Rejection Fault Tolerant Controller for A PMSM System in Unbalanced Load Fault: Design and Hardware Implementation

Luo, Lin — Yangzhou Univ.
Sun, Song — Yangzhou Univ.
Li, Juan — Southeast Univ.
Li, Shengquan — Yangzhou Univ.

Aiming at the speed fluctuation caused by the unbalanced load fault of the permanent magnet synchronous motor system, a composite active disturbance rejection fault tolerant control method is proposed in this paper. Firstly, the mathematical model of load torque is deduced based on the kinematics analysis of the fault. A model of electromechanical coupling is established with the torque coupling relationship between the motor and load. Secondly, the estimation of the fault model information from a load observer is used to improve the design of extended state observer so the influence of the fault on the performance of the whole control system can be attenuated via the feedforward compensation channel. Finally, a real time hard-in-the-loop based NI CompactRIO 9045 and LabVIEW for PMSM system is designed to verify and compare the performance of the proposed controller against conventional active disturbance rejection controller. The experiment results demonstrate the effectiveness and superiority of the proposed controller.

▶ ThurB03-4 16:40–17:00

Event-triggering-based Leader-following Consensus of Second-order Multi-agent Systems with Mismatched Disturbances

Jiayi, Gong — Nankai Univ.
Wang, Fuyong — Nankai Univ.
Liu, Zhongxin — College of Artificial Intelligent, NanKai Univ.
Chen, Zengqiang — Nankai Univ.

In this paper, leader-following consensus of second-order multi-agent systems with mismatched disturbances and matched disturbances are discussed. First, a nonlinear disturbance observer is used for each follower to estimate disturbances. Then, distributed event-triggering strategy is designed and Zeno-behavior is excluded. Moreover, based on the disturbance estimation and distributed event-triggering strategy, distributed control law is proposed to guarantee that the states of followers are able to tract the state of single leader. Finally, the effectiveness of the theoretical results are verified by a simulation example.

▶ ThurB03-5 17:00–17:20

Compensation Function Observer-based Backstepping Control and Application in Quadrotor UAV

Deng, Jiahao — Tiangong Univ.
Qi, Guoyuan — Tiangong Univ.

The backstepping control obtains the feedback controller by recursively constructing the Lyapunov function of the closed-loop system, and has the advantage making the system error exponential convergence under accurate model. Therefore, it has been widely used in nonlinear systems control. In recent years, with the development of composite materials, power systems, sensors, and other technologies, the research of unmanned aerial vehicle (UAV) systems represented by quadrotors has been rapidly developed. The design and research of the quadrotor UAV control system have increasingly become the focus of attention. The backstepping control has two problems: "differential explosion" and control accuracy depends on model accuracy. For problem one, this article introduces a high order differentiator extracting the differential information of the signal up to the -order, and has higher accuracy and better filtering performance. For problem two, the quadrotor UAV dynamics model is highly nonlinear and coupled, which is difficult to obtain accurate model. Even if a more accurate mathematical model is established, it will inevitably be affected by the internal structure and external disturbances in real flight. The extended state observer (ESO) has been applied to estimate the unknown function and disturbance in the nonlinear model; however, the estimate accuracy is problematic because of low type. The compensation function observer (CFO) with a higher type achieves a higher accuracy for estimate the unknown model or disturbance than the ESO. A CFO based backstepping control (CFO-BC) is designed using the extracted differentials and the estimated model functions using the CFO. The stability of the closed-loop system is theoretically proved by the Lyapunov function. The scheme can effectively suppress the unknown disturbances of the system. In order to verify the performance and effectiveness of the proposed control method, based on the quadrotor UAV attitude experiment conducted on the Pixhawk control test platform, three control schemes: the CFO-BC, traditional backstepping control (T-BC), and ESO-based backstepping control (ESO-BC), are used to carry out four experiments of tracking different attitude angles and anti-interference for the quadrotor UAV. The results show that the proposed CFO-based scheme is superior than the other two schemes in accurate tracking performance, system transient performance, anti-interference ability, and unknown information estimation ability.

▶ ThurB03-6 17:20–17:40

CFO-based Model Compensation Control and Its Application in QUAV Trajectory Tracking

Li, Xia — Tiangong Univ.
Qi, Guoyuan — Tiangong Univ.

As a typical vertical take-off and landing helicopter, the quadrotor UAVs (QUAV) have more and more diversified application scenarios and richer research contents. In recent years, there have been many excellent theoretical research achievements on robust stability control of quadrotor for its characteristics of difficult to establish accurate model, heavy couplings, uncertain parameters and sensitivity to external disturbance, but few control algorithms are simple and convenient to implement in practice. The widely studied sliding mode control (SMC) based on Lyapunov

function is a robust controller, which utilizes a high frequency switching control signal to enforce the system trajectories onto a surface in finite time, i.e., the so-called sliding surface which is designed to achieve desired pole. But the SMC technology mainly has the following problems: (1) the system model should be assumed to be known; (2) requires a known upper bound of the external disturbance; (3) chattering occurs in the control input and/or in the state. Unfortunately, the dynamic system and mechanical system parameters of quadrotor UAV are changing in real time, so it is difficult to establish an accurate dynamic model, that is, only part of the model information can be known. The other unknown model parts and external disturbances cannot be predicted, and their upper bounds cannot be determined. The chattering phenomenon directly damages the actuator, which must be avoided in practice. These strict conditions limit the practical application of SMC. The compensation function observer (CFO) is a novel model function observer, which compensates the system unknown model function using a compensator, and realizes the estimation error convergence to zero for the unknown function with third-order derivative is zero. It is a three-type system that has been proven, two types higher than the ESO. Therefore, the estimation accuracy of unknown model functions using CFO is greatly improved compared with ESO, and the CFO provides an attractive solution to the issue of high precision motion control system. Motivated by the above observation, a new model compensation control (MCC) combined CFO and SMC is proposed in this paper for QUAV to tracking the reference trajectory. The high-order differentiator (HOD) is used to extract the approximations of the differential and second-order differential of given reference trajectory. The CFO is used to estimate the system output and its differential and unknown model function of each subsystem with uncertainties, coupling terms and external disturbances. Thus, the estimated model information is compensated in the traditional SMC to ensure the stability of the closed-loop system and the robustness to disturbances and unknown uncertainties. The developed algorithm effectively reduces the switching gain in SMC and achieves chattering-free control input. The tracking performance of the traditional SMC, the ADRC based on the ESO and the proposed MCC based on the CFO for the QUAV system with gust wind is compared by simulation, the considerable improvement of the proposed method is verified.

ThurB04 15:40–17:40 Room 5

Invited Session: Explainable Fault Diagnosis and Performance Optimization

Organizer: Chen, Hongtian — Univ. of Alberta
Organizer: Huang, Darong — Chongqing Jiao-tong Univ.
Organizer: Shang, Chao — Tsinghua Univ.
Chair: Chen, Hongtian — Univ. of Alberta
Co-Chair: Shang, Chao — Tsinghua Univ.

▶ ThurB04-1 15:40–16:00

Convolutional Neural Networks-aided Canonical Correlation Analysis to Fault Classification

Yang, Xinyu — Inst. of Computer Sci. & Engineering, Changchun Univ. of Tech.
Zhai, Shuang — Changchun Univ. of Tech.
Cheng, Chao — School of Computer Sci. & Engineering, Changchun Univ. of Tech.
Chen, Hongtian — Univ. of Alberta

In industrial, the data are multivariable, high-dimensional, and nonlinear. Therefore, it is impossible to extract sufficient information from the process data in time. To solve this problem, this paper proposes a fault classification method based on the canonical correlation analysis (CCA) assisted by convolutional neural network(CNN). The proposed method bears data feature extraction at Case Western Reserve University and performs multiple fault classification. The experimental results verified the applicability and effectiveness of the proposed method.

▶ ThurB04-2 16:00–16:20

A Segmental Autoencoder-based Fault Detection for Nonlinear Dynamic Systems: An Interpretable Learning Framework

Chen, Hongtian — Univ. of Alberta
Pan, Zhuofu — Central South Univ.
Dogru, Oguzhan — Univ. of Alberta
Wang, Yalin — Central South Univ.
Huang, Biao — Univ. of Alberta

This paper presents a segmental autoencoder-based fault detection (FD) framework for nonlinear dynamic systems. The basic idea behind the proposed FD scheme is to identify a generalized kernel representation based on the representation knowledge learned from an autoencoder. By using the system data, several cascades, linking nonlinear operators, are employed to obtain a data-based model which describes the nonlinear dynamic behaviors. With the help of the segmental structure of an autoencoder, a residual generator is then constructed. Rigorous mathematical analysis and an application on a continuous stirred tank reactor demonstrate the effectiveness of the proposed FD method.

▶ ThurB04-3 16:20–16:40

Consensus Control of Heterogeneous Time-varying Multi-agent Systems under Multiple Sensors

Xiang, Guoliang — SUZHOU Univ. OF Sci. & Tech.
You, Renyang — Suzhou Univ. of Sci. & Tech.
Guo, Shenghui — Suzhou Univ. of Sci. & Tech.

A linear optimal data fusion algorithm is proposed for a class of heterogeneous time-varying multi-agent systems with multiple sensors in a single intelligence, and the data fusion step of the single intelligence is completed according to the Kalman filter algorithm. A consensus control protocol is then set according to the optimal estimate of the data fusion to achieve consistency control, and the final simulation shows the effectiveness of the proposed algorithm.

▶ ThurB04-4 16:40–17:00

Process Monitoring of Operational Cost for Wastewater Treatment Processes Using Variants of ARMA Models Based Soft-sensors

Lu, Yu — South China Univ. of Tech.
Liu, Yiqi — South China Univ. of Tech.
Li, Dong — South China Univ. of Tech.

Process monitoring of operation cost index (OCI) is of great importance for wastewater treatment plants (WWTPs), which is not only able to support financial budget, but also to optimize local operation. This paper proposed four variants of auto-regressive and moving average (ARMA), based on recursive least squares algorithm (RLS), ARMA based on recursive extended least squares algorithm (RELS), nonlinear auto-regressive neural network (NARNN), and nonlinear auto-regressive neural network with external input (NARXNN) respectively, to predict the operating cost in WWTP. The proposed methods were validated in the simulation platform, Benchmark Simulation Model No.2-P (BSM2-P). On account of the strong nonlinearity of the wastewater treatment process, the nonlinear model, like NARXNN, achieved better performance in terms of mean square error (MSE) and correlation coefficient (R).

▶ ThurB04-5 17:00–17:20

Enhanced Discriminant Analysis Based Fault Diagnosis Scheme for Marine Diesel Engines

Zhong, Kai — Anhui Univerisity
Jiayi, Wang — Anhui Univ.
Pan, Donghui — Anhui Univ.

Since the marine diesel engine is one of the most popular power equipments for modern shipping, accurate and timely diagnose the faults occurred in diesel engine is extraordinary important for long service life and high reliability. Note that Fisher discriminant analysis (FDA) has been widely applied in fault diagnosis field. However, it is quite susceptible to the small sample size (SSS) problem, which is very common in the running process of diesel engine. In response to the problem, this study proposes a new fault classification criterion based exponential discriminant analysis (EDA) scheme for diesel engine fault diagnosis, in which the exponential transformation is carried out first to enlarge the margin between different classes, thus the different fault classes are further separated and the diagnosis capability is enhanced. In addition, the theorems of matrix exponential guarantee that the matrix exp(Sw) is always full-rank, even though the Sw is singular. That means, the novel methodology is still applicable when confronts with the SSS problem. Finally, based on the more reasonable fault classification criterion, the simulation results on a real-world two-stroke six-cylinder low-speed marine diesel engine indicate that the EDA based diagnosis scheme achieves higher fault diagnosis accuracy with good robustness and practicability in real-world engineering application.

▶ ThurB04-6 17:20–17:40

基于慢变化准则的工业大数据解析及故障诊断方法

Shang, Chao — Tsinghua Univ.

自2006年以来，以深度学习为代表的大数据解析技术得到了蓬勃发展，在语音识别、计算机视觉等领域中取得了巨大的成功。深度学习背后的表示学习（Representation Learning）思想强调“特征”的重要性，即特征表达须真实反映研究对象的本质变化。基于表示学习的建模方法在控制领域同样引起了广泛关注，而问题关键在于如何针对研究对象特性设

计模型特征。本报告拟介绍一种代表性方法——基于慢特征分析（Slow Feature Analysis）的过程数据解析框架，与传统方法相比其特点在于，通过将典型过程动态特性归纳为“特征变化缓慢”的先验知识，显著地改善了模型的可解释性，在多元统计监控、故障诊断、软测量与振荡检测中均显示了良好的实用性。在此基础上，探讨工业过程控制优化中亟待解决的难题，并对未来的研究方向提出展望。

ThurB05 15:40–17:40 Room 6

Regular Session: Data-driven Modeling, Optimization and Scheduling (I)

Chair: Liu, Qie — Chongqing Univ.

Co-Chair: Xu, Bao-Chang — China Univ. of Petroleum ,Beijing

▶ ThurB05-1 15:40–16:00

A Robust Two-step Iterative Approach for the Identification of Hammerstein Box-Jenkins Systems

Xu, Bao-Chang — China Univ. of Petroleum ,Beijing
Zhu, Shiyuan — China Univ. of Petroleum
Wang, Yaxin — China Univ. of Petroleum-Beijing
Yuan, Likun — China Univ. of Petroleum, Beijing
Wang, Zhu — China Univ. of Petroleum (Beijing)

Impulse interference widely exists in engineering practices, and makes the noise disturbance of the system present a heavy-tailed distribution. Therefore, the performance of traditional parameter estimation methods based on Gaussian noise assumption will be seriously degraded when used in the system affected by heavy tail noise. Since industrial objects usually have nonlinear characteristics, this paper takes Hammerstein Box-Jenkins model as the object under the background of heavy tail noise，and proposes a novel two-step iterative robust identification method based on the least absolute criteria. Firstly, the Gaussian mixture model is used to generate the input signal to distinguish the influence of nonlinear characteristic and heavy-tailed noise. Secondly, a two-step iterative identification method based on least absolute criteria is proposed. The two-step iterative method not only guarantees a global optimal parameter estimation of the model, but also avoids the non-convergence of noise model estimation. Finally, the identification experiments on nonlinear model affected by heavy-tailed noise with Student’s t distribution proved the effectiveness of the proposed method. Compared with other identification algorithms, the proposed algorithm has better robustness to heavy-tailed noise.

▶ ThurB05-2 16:00–16:20

Interval Type-2 Dynamic Fuzzy Neural Network with Tensor Inverse

Hu, Jiale — Inner Mongolia Univ.
Zhao, Guoliang — Heilongjiang Univ. of Sci. & Tech.
Huang, Sharina — Heilongjiang Univ. of Sci. & Tech.
Dai, Huhe — Inner Mongolia Univ.

Fuzzy neural network is a research hotspot in the field of artificial intelligence. Among them, for the dynamic fuzzy neural network, it dynamically prunes the nodes according to the performance index, which proves that it can enhance the training model with dynamic parameters. However, due to over-fitting, the test error is large and the applicability in practical application is low. Therefore, this paper applies interval type 2 fuzzy sets to dynamic fuzzy neural networks with new consequent learning algorithm, and proposes an interval type 2 dynamic fuzzy neural network with tensor inversion, the test error is reduced, and the anti-interference ability of the network is improved with the hybrid strategy, comparable results are obtains among many intelligent algorithms.

▶ ThurB05-3 16:20–16:40

Non-iterative Estimation Algorithm for Time-delay Hammerstein State Space System

Sun, Xueqi — Jiangsu Univ. of Tech.
Li, Feng — Jiangsu Univ. of Tech.
Cao, Qingfeng — Yangzhou Univ.

This paper aims at the parameter estimation method for time-delay Hammerstein state space system. The Hammerstein system studied is composed of a static nonlinear module approximated by a neural fuzzy model and a dynamic linear module modeled by a time-delay state space model, and input test signals which is composed of separable signals and random signals are applied to parameter separation estimation of the time-delay Hammerstein system. Firstly, according to the properties of the unit backward operator, the time-delay state space system is transformed into a transfer function, and the parameters of the linear module are estimated by using correlation analysis method based on Gaussian signals. Moreover, clustering and Taylor series expansion methods are used to estimate nonlinear module, that is, the neuro fuzzy model parameters. The simulation results show the proposed method can effectively estimate the time-delay Hammerstein state space system.

▶ ThurB05-4 16:40–17:00

A 2D UAV Path Planning Method Based on Reinforcement Learning in the Presence of Dense Obstacles and Kinematic Constraints

Tang, Xinming — Chongqing Univ.
Chai, Yi — Chongqing Univ.
Liu, Qie — Chongqing Univ.

The complex kinematic constraints and dense obstacles are always the huge challenge in the UAV path planning. To effectively deal with dense obstacles and kinematic constraints, a novel two-level optimization algorithm for unmanned aerial vehicles (UAVs) in 2D maps, called as Spherical Expansion-Proximal Policy Optimization (SE-PPO), is proposed in this paper. This method is a combination of SE and PPO algorithms. In the first level, SE algorithm is used to generate the initial path, and subgoals are selected from this path in the first level. These subgoals are optimized by the local path optimizer based on PPO algorithm to obtain the final path. The effectiveness of this method to deal with the kinematic constraints and dense obstacles is demonstrated by the results of the simulation experiments.

▶ ThurB05-5 17:00–17:20

Carrier Aircraft Scheduling Optimization Based on A Algorithm and Genetic Algorithm*

Li, Mingwei — Southwest Jiaotong Univ.
Qin, Na — Southwest Jiaotong Univ.
Zhu, Tao — Southwest Jiaotong Univ.

In the whole aircraft carrier combat system, it has always been an important issue to realize the rapid take-off of carrier aircraft. Previous articles tend to pay more attention to the problems of path planning and deck processing, rarely consider the integration of the whole process, and do not consider the situation that the carrier aircraft are on the deck and hangar at the same time. In this paper, the double-layer space of the aircraft carrier is considered, which allows the aircraft to realize the operation of the deck arriving from the hangar through the elevator. On this basis, the process of sortie on aircraft carrier is studied from the perspective of the whole scheduling. The process of sortie is divided into five steps: task allocation, ascending to the deck, taxiing to the preparation position, completing takeoff inspection, takeoff and baffle recovery. Firstly, the plane model of the aircraft carrier is established, the obstacles and key positions are marked, the A* algorithm is used to search the path for each carrier aircraft, and the delayed start strategy is used to avoid obstacles in the process of traveling. The idea of job shop scheduling is used to arrange the dispatch sequence for carrier aircraft, and the best sortie scheme is selected by genetic algorithm. Finally, through the simulation of the algorithm, the feasibility of the model and the effectiveness of the algorithm are verified.

▶ ThurB05-6 17:20–17:40

A Train Cooperative Operation Optimization Method Considering Passenger Comfort Based on Reinforcement Learning

Wang, Xingguo — Inst. of Sys. Sci. & Tech.
Wu, Yue — Southwest Jiaotong Univ.
Huang, Deqing — Southwest Jiaotong Univ.
Zhu, Lei — Southwest Jiaotong Univ.
Lu, Zheng — Southwest Jiaotong Univ.
He, Yan — Southwest Jiaotong Univ.

This paper mainly focuses on the high-speed train cooperative operation problem, considering passenger comfort. To solve this problem, a speed curve optimization method based on Reinforcement Learning algorithm is proposed. First, according to the train dynamics system, we build the speed curve optimization object. For realizing the train cooperative operation and increasing the passenger comfort, trains distance constraint and jerk rate constraint are fully considered in formulating reward function. And then, agent of Reinforcement Learning is established. Agent consists of Q value networks and policy networks, which are respectively established by fully connected neural networks with different structures. Also, the training parameters are set up, such as training termination conditions, maximum number of steps, desired global reward value, and so on. After the training. The Agent can generate a desirable speed curve of train based on constraints of vehicle output and jerk rate under cooperative operation.

Friday, August 5, 2022

FriA01 08:00–10:00 Room 1
Regular Session: Iterative Learning Control (II)

Chair: Shen, Dong — Renmin Univ. of China
Co-Chair: Li, Xiao-Dong — Sun Yat-sen Univ.

▶ FriA01-1 08:00–08:20
Linear Active Disturbance Rejection Magnetic Levitation System Based on Cuckoo Search

Wei, Libing — Jiangxi Univ. of Sci. & Tech.
Fan, Kuangang — Jiangxi Univ. of Sci. & Tech.
Zhou, Xiaohua — Jilin Univ.
Hu, Lingfeng — School of Electrical Engineering & Automation
Tan, Wengang — Shandong Urban Construction Design Inst.

Magnetic levitation system has the characteristics of nonlinear, uncertainty, and multiple disturbances. Traditional controllers are difficult to achieve better control effects. In order to improve the stability and anti-interference performance of the controller, a linear active disturbance rejection control (LADRC) based on cuckoo search is proposed and validated. The control performance of the proposed method is analyzed. Besides, to verify the effectiveness of the proposed parameter tuning strategy, we analysed the anti-interference ability and tracking effects of PID and LADRC under other intelligent algorithms in different cases. The result shows that the LADRC under cuckoo search has obvious technical advantages in terms of dynamic response, robust and tracking performance.

▶ FriA01-2 08:20–08:40
Iterative Learning Control for Multi-Agent Systems over Unknown Fading Networks

He, Xun — Renmin Univ. of China
Jiang, Hao — Renmin Univ. of China
Shen, Dong — Renmin Univ. of China

This paper studies the consensus problem for multi-agent systems over unknown fading networks. The directed graph is used to describe the communication between agents. The process of fading is modeled by a random variable multiplied by the original signal. It is the first time to study the effect of unknown fading networks in a distributed structure. An iterative estimation is presented to obtain the statistical property of fading networks. Moreover, a distributed learning control scheme is proposed to establish the learning consensus performance. The input errors for all agents are strictly proved convergent to zero in the mean-square sense. In the end, numerical simulations are presented to verify the proposed scheme.

▶ FriA01-3 08:40–09:00
Discrete-Time Integral Terminal Sliding Mode Based Repetitive Control for Periodic Motion Tracking

Feng, Zhao — Univ. of Macau
Ling, Jie — Nanjing Univ. of Aeronautics & Astronautics
Shen, Yayi — Nanjing Univ. of Aeronautics & Astronautics

The high precision position tracking in many industrial and scientific devices is vital for various tasks. Among these, periodic signals are commonly used in the condition that the references are given or planned in advance. In this paper, a discrete-time integral terminal sliding mode based repetitive control (DTITSMRC) is developed for periodic motion tracking. The discretetime integral terminal sliding surface is employed for a fast convergence, and the repetitive control law with this sliding surface is integrated into the control scheme to further improve the performance through learning the information of the previous period. The quasi sliding mode band (QSMB) constrained for any initial state and the finite-time steps to QSMB with DTITSMRC are proven respectively. The simulation results on a discrete-time system demonstrate the effectiveness on periodic motion tracking for various signals.

▶ FriA01-4 09:00–09:20
Discrete Active Disturbance Rejection Iterative Learning Control Based on Dynamic Linearization

Ai, Wei — South China Univ. of Tech.
Li, Xinling — South China Univ. of Tech.
Li, Xiangyang — South China Uni. of Tech

A discrete active disturbance rejection iterative learning control method based on dynamic linearization is proposed for a class of discrete-time, nonlinear and non-affine system that run repeatedly within a finite time. The controlled system is dynamically linearized into an affine form related to the control input within the iteration domain. The control gain is initialized through the pseudo partial derivative of dynamic linearization model when needed and then fixed. The estimated errors of parameter, system uncertainty and external disturbance are compacted into a nonlinear term as the total disturbance of the system. Via iterative sliding mode scheme, the iterative extended state observer is designed to estimate the total disturbance and a discrete active disturbance rejection iterative learning control law is proposed. The convergence of the iterative extended state observer and tracking errors of the system are analyzed. The proposed method is a new intuitive and concise data-driven control method which does not need the system model information. The effectiveness of the proposed method is verified by simulations.

▶ FriA01-5 09:20–09:40
Stability of Linear Hyperbolic Distributed Parameter Systems Based on Event-triggered Control

Ni, Min — Guangxi Univ. of Sci. & Tech.
Dai, Xisheng — Guangxi Univ. of Sci. & Tech.,
Zhang, Jiaming — Guangxi Univ. of Sci. & Tech.
Wu, Qiqi — Guangxi Univ. of Sci. & Tech.
Zuo, Huang — Guangxi Univ. of Sci. & Tech.

This paper investigates the stability for a class of linear hyperbolic distributed parameter systems based on event-triggered control. Lyapunov technique is used to obtain the stable feedback gain and boundary conditions of the system. Sufficient conditions have been established for the exponential stability of the system under linear boundary condition and dissipative boundary condition. In addition, the existence of positive upper bound between two triggering times is proved. A numerical example illustrates the proposed methods.

▶ FriA01-6 09:40–10:00
Data-Driven Norm-Optimal-Gain-Adaptive Iterative Learning Control for LDTI Systems

Liu, Chuyang — Xi'an Jiaotong Univ.
Ruan, Xiaoe — Xi'an Jiaotong Univ.

For a class of repeatable linear discrete time-invariant systems, the paper constructs a data-driven norm-optimal-gain-adaptive iterative learning control scheme. The scheme is sequentially processed in an interactive mode. The estimation of the system Markov parameters is updated by minimizing the discrepancy between the estimated system output and the real output, utilizing system input and output data from previous iterations, thereby omitting the time-consuming system identification process. Simultaneously, the estimated Markov parameters are adopted for formulating the learning-gain vector of iterative learning control in the light of minimizing the weighted sum of the quadratic norm of the learning compensation vector and the tracking-error vector. Numerical simulations reveal the feasibility of the proposed scheme to achieve trajectory tracking while declining the estimated error of system Markov parameters.

FriA02 08:00–10:00 Room 3
Invited Session: Repetitive Control and its Recent Advance in Practice

Organizer: Ye, Yongqiang — Nanjing Univ. of Aeronautics & Astronautics
Organizer: Quan, Quan — Beihang Univ.
Chair: Ye, Yongqiang — Nanjing Univ. of Aeronautics & Astronautics
Co-Chair: Quan, Quan — Beihang Univ.

▶ FriA02-1 08:00–08:20
Error-driven Tracking Control Design with Preset-Input LMS Adaptive Filter

Liu, Qingquan — Harbin Inst. of Tech.
Huo, Xin — Harbin Inst. of Tech.
Liu, Kang-Zhi — Chiba Univ.
Zhao, Hui — Harbin Inst. of Tech.
Wu, Aijing — Harbin Inst. of Tech.

There is a problem of insufficient reference tracking accuracy in servo system driven by permanent magnet synchronous motor (PMSM), which limits its application. This paper aims to propose a modified error-driven preset-input least mean square adaptive filter (EPLMS-AF) to improve the tracking accuracy. The reference tracking error is used to drive the update of adaptive weights in EPLMS-AF. The designed preset-inputs makes the reference tracking error converge to zero according to the form of reference. On the premise of choosing an appropriate iteration size to ensure the stability of the filter, the tracking error is able to re-

duce to zero along the gradient direction. At last, numerical simulations are provided to illustrated the high efficiency and wide applicability if the proposed method.

▶ FriA02-2 08:20–08:40

Adaptive Repetitive Control for A Class of Uncertain Nonlinear Systems Based on Additive-state-decomposition and Dynamic Surface Technique

Sun, Yongbo — Hunan Univ. of Sci. & Tech.
Zhou, Lan — Hunan Univ. of Sci. & Tech.
Jia, Fengyi — Hunan Univ. of Sci. & Tech.
Gao, Dongxu — Hunan Univ. of Sci. & Tech.

This paper presents an adaptive repetitive control (RC) method for a class of uncertain nonlinear systems with mismatched disturbances based on additional-state-decomposition and dynamic surface technique. First, the original tracking problem for uncertain nonlinear system is decomposed into two subproblems, namely RC problem for linear time-invariant (LTI) primary system and robust stabilization problem for uncertain nonlinear secondary system with mismatched disturbances. For LTI primary system, modified RC is used to deal with periodic signals. In addition, the time-delay constant of the repetitive controller is corrected in the frequency domain, which further improves the tracking performance. For uncertain nonlinear system secondary system, backstepping control is used to deal with mismatched disturbances, and dynamic surface technique is used to avoid "explosion of terms" in backstepping design. Under the designed composite controller, all signals of the closed-loop system are proven to be semi-globally bounded and the system output quickly tracks the reference signal. Finally, numerical results illustrate the validity and superiorities of the method.

▶ FriA02-3 08:40–09:00

Analysis and Design of Repetitive Control Composite Controller for Grid-tied Inverter

Chen, Sainan — Nanjing Univ. of Aeronautics & Astronautics
Ye, Yongqiang — Nanjing Univ. of Aeronautics & Astronautics

The high gain characteristic of repetitive control makes it have excellent reference current tracking ability and harmonic suppression ability, but due to the inherent delay link, the dynamic response is slow. Therefore, repetitive control (RC) is usually combined with other controllers with good dynamic performance in inverters. Commonly used is the composite control form of series or parallel of repetitive control and proportional integral control (PI). This paper analyzes the series or parallel forms of RC and P/PI. The simulation results show that the RC series P has fewer design parameters and simpler structure than the other three combinations, and has better harmonic suppression ability, faster dynamic response speed and robust performance against grid frequency fluctuations.

▶ FriA02-4 09:00–09:20

Sampled-data Repetitive Control for A Class of Non-minimum Phase Nonlinear Systems Subject to Period Variation

Quan, Quan — Beihang Univ.

The sampled-data robust repetitive control (RC, or repetitive controller, also designated RC) problem for nonminimum phase nonlinear systems is both challenging and practical. This paper proposes a sampled-data output-feedback RC design for a class of nonminimum phase systems subject to measurable nonlinearities to improve the robustness for the period variation. The design relies on additive state decomposition, by which the output-feedback RC problem is decomposed into an output feedback RC problem for a linear time-invariant component and a state-feedback stabilization problem for a nonlinear component. Thanks to the decomposition, existing controller design methods in both the frequency domain and time domain can be employed together to make the robustness and discretization for a nonlinear system tractable. To demonstrate the effectiveness, an illustrative example is given.

▶ FriA02-5 09:20–09:40

Frequency Adaptive Feedforward Odd-Harmonic Repetitive Control for A Grid-Tied Inverter

Zhang, Gong — Zhongyuan Univ. of Tech.
Zhao, Qiangsong — Zhongyuan Univ. of Tech.

In this paper, a feedforward odd-harmonic repetitive control (FORC) scheme is proposed. The FORC consists of a proportional control in parallel with a modified odd-harmonic repetitive control with a feedforward channel, which leads FORC to have a much larger gain and a wider bandwidth at odd-harmonic frequencies than conventiaonal ORC without a feedforward channel. However, the performance of FORC will degrade when the grid frequency fluctuates in a large range. Therefore, based on a Thiran infinite impulse response (IIR) filter, this paper presents a frequency adaptive FORC (FAFORC) scheme to make sure that the resonant frequencies match the actual reference frequency and harmonic frequencies by online adjusting only a few coefficients of low-order IIR filter. The stability analysis, parameters design, and performance evaluation are given. Experimental results demonstrate the effect and feasibility of the proposed FA-FORC scheme.

▶ FriA02-6 09:40–10:00

Unknown System Dynamics Estimator-Based Fast Nonsingular Terminal Sliding Mode Control for An Omnidirectional Mobile Robot

Zhang, Fangfang — Kunming Univ. of Sci. & Tech.
Na, Jing — Kunming Univ. of Sci. & Tech.
Yang, Chunxi — Kunming Univ. of Sci. & Tech.
Huang, Yingbo — Kunming Univ. of Sci. & Tech.

This paper proposes a new control method for the omnidirectional mobile robot (OMR) system with unknown dynamics and disturbances. An unknown system dynamics estimator (USDE) is developed by introducing low-pass filter operations to estimate the unknown dynamics and external disturbances, and only one parameter of the USDE needs to be tuned. Moreover, a new fast nonsingular terminal sliding mode control (FNTSMC) scheme is developed to overcome the singularity and slow convergence rate of the terminal sliding mode control (TSMC) method. Finally, we combine the proposed USDE and FNTSMC schemes to design a feedback controller to guarantee tracking control accuracy of the omnidirectional mobile robot system. In addition, stability analysis of the proposed USED and FNTSMC methods is presented via the Lyapunov theory, and the performance of the proposed control scheme is verified by the simulation.

FriA03 08:00–10:00 Room 4

Regular Session: Data-driven Modeling, Optimization and Scheduling(II)

Chair: Liu, Han — Xi'an Univ. of Tech.
Co-Chair: Qin, Na — Southwest Jiaotong Univ.

▶ FriA03-1 08:00–08:20

*Multiple Carrier UAV Path Planning Based on Hybrid A**

Zhu, Tao — Southwest Jiaotong Univ.
Qin, Na — Southwest Jiaotong Univ.
Huang, Deqing — Southwest Jiaotong Univ.
Li, Mingwei — Southwest Jiaotong Univ.
Mao, Yongjie — Southwest Jiao Tong Univ.
Chen, Dewang — Southwest Jiaotong Univ.

Unmanned aerial vehicle(UAV) are becoming more and more important in modern warfare, and future carrier UAVs will also be indispensable for the improvement of aircraft carrier combat capabilities. Taking into account the future trend of unmanned combat and the ease of dealing with the environment such as path planning in the hangar, the carrier UAV in this article needs to consider reversing motion. Based on this, a mathematical model for path planning is established and a hybrid A-star algorithm is introduced. The path planning problem of shipborne UAV. In addition, the previous multi-carrier UAV path planning did not consider the impact of the dispatch process, so this paper proposes a conflict avoidance strategy for multi-carrier UAV path planning. The simulation results show that the hybrid A* is effective in the path planning of carrier UAVs, and the proposed multi-carrier UAV conflict avoidance strategy can fully meet the given constraints. It shows that the method proposed in this paper can effectively cope with the path planning task of carrier UAV.

▶ FriA03-2 08:20–08:40

A Novel Soft Sensor Model Based on Stacking Ensemble Learning Framework

He, Zhao — Xi'an Univ. of Tech.
Liu, Han — Xi'an Univ. of Tech.

In this paper, an auxiliary variable selection method based on the coefficient of variation and maximum mutual information coefficient (CV-MIC) is proposed to select the most favorable variables for the model as auxiliary variables. On this basis, a new soft sensing model based on stacking ensemble learning framework is established. The model uses LSTM-GPR, SDAE-SVR and XGBoost soft sensing methods as the base learner for ensemble learning, and DNN as the meta-learner for ensemble learning to combine the base learners. To verify the effectiveness of the proposed method, the model is applied to the prediction of the rotor deformation of the boiler air preheater in thermal power plants. The experimental results show that the soft sensor model based on ensemble learning has higher prediction accuracy than the traditional single-model

soft sensor method.

▶ FriA03-3 08:40–09:00

Wind Power Prediction Based on the Stacking Model of XGBoost and Random Forest

Liu, Wang-Jie Shanghai Univ.
Jia, Li Shanghai Univ.

Due to the uncontrollability of wind energy, the conversion efficiency of wind is low. By improving the prediction accuracy of wind power, the conversion efficiency of wind energy can be greatly improved. For the purpose of solving the problems of overfitting of most wind power prediction models, the over-dependence of wind speed and the ignorance of other important features, this paper proposes a stacking method to integrate two models: XGBoost and Random Forest. Stacking of these two models can solve the above problems and greatly improve wind power prediction accuracy. The dataset from Kaggle verifies that the stacking model can extract the useful information contained in the data effeciently and has better accuracy than a lot of mainstream models. The evaluation metrics Mean Squared Error(MSE) and R2 of the stacking model are reduced by about 10% compared with the mainstream models.

▶ FriA03-4 09:00–09:20

Research on Optimal Resource Allocation of UAV Customized Cloud Platform Based on Bi-level Programming

Wu, Yanxia Sys. Engineering Research Inst., China State Shipbuilding Corporation Limited
Yang, Li Sys. Engineering Research Inst.
Wang, Hao Sys. Engineering Research Inst., China State Shipbuilding Corporation Limited
Fan, Yao Sys. ENGINEERING RESEARCH Inst.
Qiu, Xingye Sys. Engineering Research Inst.
Zhang, Youshan Sys. Engineering Research Inst.,China State Shipbuilding Corporation Limited
Li, Ling Sys. Engineering Research Inst., China State Shipbuilding Corporation Limited
Liu, Geng Sys. Engineering Research Inst.

Aiming at the optimal resource allocation of UAV customized cloud platform (UAV-CCM), this paper considers the sustainability of cloud platform at the operational level, and introduces the sustainability evaluation indicators of UAV-CCM from three aspects of economy, environment and society. We propose a multi-objective bi-level programming resource allocation (MOBPRA) model of UAV-CCM. The model maximizes the sustainability and quality of service of UAV-CCM from the perspective of the platform operator and multiple service demanders. In order to solve the established MOBPRA model, a new hybrid algorithm of particle swarm optimization and simulated annealing (PSO-SA) is proposed. Finally, the bi-level programming model and PSO_ SA algorithm is applied to UAV-CCM to further verify its feasibility. The results demonstrate the feasibility and effectiveness of the proposed model and algorithm.

▶ FriA03-5 09:20–09:40

Research on the Structure Model of Knowledge Manufacturing and Service System of Smart Library Based on Super-network

Wei, Qiongqiong Qingdao Univ. of Sci. & Tech.
Zhu, Yanshuo Qingdao Univ. of Sci. & Tech.

The knowledge manufacturing and service system of the smart library is the model of knowledge service and management of the library in the future. Based on the super-network theory, the super-network characteristics of a knowledge manufacturing and service system of smart library is analyzed. The super-network modeling method of "two-layer four-network" knowledge manufacturing and service system of smart library is built. The paper scientifically expresses the operation mode of the knowledge manufacturing and service system of the smart library, and provides a theoretical basis for the library to implement the digital modeling of the smart library in an all-round way.

▶ FriA03-6 09:40–10:00

An Optimization Method for Multi-Train Coordinated Energy-Saving Operation in Metro System

Huang, Deqing Southwest Jiaotong Univ.
Cai, Hanlin School of Tangshan Graduate

This study explores the energy-saving cooperative control of multiple trains under the constraint of the timetable, focusing on improving the utilization of regenerative braking energy. According to the actual traffic organization characteristics of the metro system, the operation time domain is decomposed into multiple identical optimization time domains. In each optimization time domain, through the time distribution characteristics of unused regenerative braking energy in the power supply interval, the sections in which the net energy consumption of each train should be reduced are determined. In the determined sections of each train, the control strategies are optimized to reduce the total energy consumption. Taking the available regenerative power in the power supply interval as the input and considering the practical operation constraints, an energy-saving control model is proposed to minimize the net energy consumption. The simulation results show that the cooperative control method in this paper can make great use of regenerative braking energy and reduce the total energy consumption while retaining the energy-saving effect of the timetable.

FriA04 08:00–10:00 Room 5

Regular Session: Applications of Data-driven Methods to Industrial Processes

Chair: Han, Yongming Beijing Univ. of Chemical Tech.
Co-Chair: Ji, Honghai North China Univ. of Tech.

▶ FriA04-1 08:00–08:20

Pipeline Network Calculation Based on Improved IN-IGA Algorithm

Cong, Di Beijing Univ. of Chemical Tech.
Li, Jun Beijing Univ. of Chemical Tech.
Han, Yongming Beijing Univ. of Chemical Tech.
Wei, Chunyang Beijing Univ. of Chemical Tech.
Geng, Zhiqiang Beijing Univ. of Chemical Tech.

Chemical process simulation can provide a more comprehensive description and analysis of chemical processes, and the solution of chemical pipeline network systems calculation is an important problem in the chemical simulation research. Therefore, an improved interval Newton-immune genetic algorithm (IN-IGA) is proposed in this paper for better self-solution of relevant parameters in chemical pipeline network system transport process simulation. The improved immune genetic algorithm is applied to determine the approximate range of solutions by fast search. Then the interval Newton method is used to obtain the nonlinear equations and calculate the high-precision results. Finally, the proposed method is applied in the calculation of chemical process pipeline networks. In comparison with the traditional Newton-Raphson (NR) method, the IN-IGA avoids the limitation of initial value selection, improves the convergence speed of the algorithm and optimizes the convergence effect, which is of great significance for chemical process simulation and modeling.

▶ FriA04-2 08:20–08:40

Active Learning-Based Complex Pipelines Weld Defect Detection with Lightweight Neural Network

Zuo, Fengyuan Northeastern Univ.
Liu, Jinhai Univ. of Northeastern
Wang, Lei Northeastern Univ.
Qu, Fuming Univ. of Northeastern
Fu, Mingrui Univ. of Northeastern

Weld defect detection plays an important role in pipeline safety maintenance. Due to the complexity of weld defects, it is difficult for existing intelligent detection methods based on deep learning to achieve high accuracy and efficiency. We propose a novel defect detection method that can better alleviate the current dilemma by constructing an active learning framework with well-designed value sample sampling strategy. First, primary defect detector is trained based on data driven by building a lightweight fully convolutional network. Then efficient value sample selection strategy is devised by computing the uncertainty of unlabeled images. Finally, fine-tuning network parameters based on value samples is proposed to obtain large performance gains with minimal resources. The experimental results on the pipeline weld defect dataset in northern China show that the proposed method has higher detection accuracy than traditional deep learning methods.

▶ FriA04-3 08:40–09:00

Secondary Reheat Steam Temperature Prediction Based on Hybrid Deep Learning

Gao, Yu Qing Southeast Univ.
Xue, Yali Tsinghua Univ.
Sun, Li Southeast Univ., Http://power.seu.edu.cn/sl/list.htm

An accurate prediction model of the secondary reheat steam temperature in the ultra-supercritical double-reheat coal-fired power plant is difficult to build due to the characteristics of strong nonlinearity, multi-variable coupling, large inertia, and various disturbances. This paper proposed a joint data-driven prediction method based on GRU-Pooling-Attention

to improve the prediction accuracy and training speed. Firstly, CatBoost algorithm is taken to calculate the importance of features, and the input feature set is selected combined with expert knowledge. Then the GRU is adopted to learn the time series relationship between data, the pooling method is embedded to reduce the number of parameters and to highlight key values, and the attention mechanism is introduced to assign different weights to the output of each time step of GRU to reflect the large delay and large inertia of the system. The hybrid deep learning method is applied to the prediction of the secondary reheat steam temperature based on historical data, and the results show that it can obtain accurate and fast multi-step prediction. The trained model can be used to explore the dynamic characteristics of the processes.

▶ FriA04-4 09:00–09:20

A Deep-Convolution-Generative-Adversarial-Networks-based Missing Data Filling Method for Blast Furnace Gas System in Steel Industry

Yang, Canguang — Dalian Univ. of Tech.
Jin, Feng — Dalian Univ. of Tech.
Zhao, Jun — Dalian Univ. of Tech.
Wang, Wei — Dalian Univ. of Tech.

The integrity of monitoring data is of great significance to ensure the accuracy of data analysis and reliable operation in blast furnace gas system of steel industry. In this study, a Deep-Convolution-Generative-Adversarial-Networks (DCGAN)-based data filling method is proposed for high proportion missing in time series, and the corresponding network structure is designed. Time series are transformed non-destructively into time domain images by a Gram matrix, and their temporal characteristics are preserved. The authenticity constraint and the context similarity are established to optimize the hidden variables, and the high-precision time-domain image is generated through the DCGAN. The completed time series is obtained by inversely transforming the Gram matrix. The simulation results based on the actual operating data of a steel enterprise indicate that the proposed method is capable of has high padding accuracy in the case of a high proportion of random missing data and continuous missing data.

▶ FriA04-5 09:20–09:40

An Automatic Train Operation Strategy Based on Prescribed Performance Control

Li, Zikang — Southwest Jiaotong Univ.
Wu, Yanzhi — Southwest Jiaotong Univ.
Huang, Deqing — Southwest Jiaotong Univ.
Cai, Hanlin — School of Tangshan Graduate

With the fast development of 5G communications, big data and intelligent control technologies, automatic train operation (ATO) is expected to supersede traditional manual driving for high-speed railway systems. To study the precise automatic control algorithm for high-speed trains (HST), a novel prescribed performance tracking control method based on the barrier Lyapunov function (BLF) is proposed in this paper. First, the dynamic model of HST with basic and additional resistances is established considering actual operating condition and actuator saturation phenomenon. Second, an auxiliary system is constructed to eliminate the negative effect caused by input saturation, and a prescribed performance tracking controller with adaptive law is designed for ATO system. Finally, the stability of the close-loop system and the boundedness of the tracking error signals are proved based on Lyapunov stability theorem. Simulation results demonstrate the effectiveness of the proposed controller.

▶ FriA04-6 09:40–10:00

Data-driven Model Predictive Control for Heterogeneous Vehicular Platoon with Subspace Identification

Wu, Yanhong — Tianjin Univ.
Zuo, Zhiqiang — Tianjin Univ.
Wang, Yijing — Tianjin Univ.

To alleviate the threat of uncertain dynamics of heterogeneous vehicular platoon, a distributed data-driven model predictive control strategy is proposed in this paper. A data-driven model of the heterogeneous vehicular platoon is constructed with a subspace identification algorithm by decomposing the input-output vehicle data. Then, the distributed model predictive control is combined with the heterogeneous vehicular platoon model to optimize the heterogeneous vehicular platoon. Together with this control strategy, an equality terminal constraint and the sum cost function are developed to ensure the stability. Eventually, some experiments with heterogeneous vehicular platoon demonstrate the effeffctiveness of the proposed strategy

FriA05 08:00–10:00 Room 6

Invited Session: Advanced Control for Fuzzy and Time Delay Nonlinear Systems

Chair: Han, Weixin — Northwestern Polytechnical Univ.
Co-Chair: Wu, Yue — Southwest Jiaotong Univ.

▶ FriA05-1 08:00–08:20

Data-Based Adaptive Integral Sliding-Mode Secure Control for Cyber-Physical Power Systems with Disturbance under Bias Injection Attacks

Han, Xinyu — Northeast Electric Power Univ.
Huang, Xin — Northeast Electric Power Univ.

This paper studies the problem of secure control of cyber-physical power systems with disturbance inputs under bias injection attacks. It is assumed that system parameter matrices are not accurately acquired on account of the influence of unknown and changeable environmental factors. Then, an off-policy reinforcement learning algorithm is first used to obtain the available parameters. Further, an integral sliding-mode function only relying on available data and parameters is given, based on which, an adaptive integral sliding-mode compensator is designed, so that the effects of actuator attacks and nonlinear disturbance inputs are able to be successfully removed and also a nearly optimal performance of the equivalent sliding-mode dynamics is ensured. Finally, the effectiveness of the proposed scheme is verified by IEEE 6 bus power system with 3 generators and 6 buses.

▶ FriA05-2 08:20–08:40

H∞ control for uncertain T-S fuzzy systems

Wu, Yue — Southwest Jiaotong Univ.
Cai, Liangcheng — Southwest JiaoTong Univ.

This paper investigates the H∞control problem for nonlinear systems with uncertainties and disturbances. Firstly, T-S fuzzy models are utilized to approximate the nonlinear systems. Then, an fuzzy control scheme with an adaptive mechanism is developed to compensate the effect of the uncertainties on the systems. In addition, to reduce the influence of the disturbance and further improve the performance of H∞control, an adaptive membership function-dependent H∞performance index is considered and the corresponding analysis conditions are obtained. Finally, a numerical example for 2-order systems is presented to show the advantage of the presented approach with the above-mentioned performance index.

▶ FriA05-3 08:40–09:00

Energy Router Optimization Strategy Based on LSTM Algorithm for Real-Time Congestion Prediction

Chen, Xu — Anhui Polytechnic Univ.
Zhang, Yan — Anhui Polytechnic Univ.

As the core equipment of the energy Internet, energy routers (ERs) can optimize energy transmission and energy scheduling in time and space, thereby improving the transmission efficiency and stability of the multi-source power network. This paper establishes a graph model of the energy transmission network based on the topological structure of energy routing. Long and short-term memory (LSTM) is introduced to predict the congestion of ERs. As a result, an energy routing optimization strategy based on LSTM for real-time congestion prediction is proposed by considering the factors of congestion and transmission loss. Then Dijkstra algorithm is applied to determine the best path for energy transmission. Finally, numerical simulation verifies the feasibility and effectiveness of the energy routing optimization strategy proposed in this paper.

▶ FriA05-4 09:00–09:20

Stabilization Control of Underactuated Cart-double-pendulum System

Fan, Lu — Linyi Univ.
Zhang, Ancai — Linyi Univ.
Li, Ning — Linyi Univ.
Zhang, Xinghui — Linyi Univ.
Pang, Guochen — Linyi Univ.

A cart-double-pendulum is an underactuated nonlinear mechanical system with three degrees of freedom (DOF) and two inputs. The stabilization control problem for this mechanical system is concerned in this paper. Based on the idea of virtual friction, three types of stabilizing controllers are designed. They are D controller, PsD controller and PD controller. The stability of closed-loop control system is analyzed by using LaSalle' s invariance principle. Simulation results verify the effectiveness of our presented control methods.

▶ FriA05-5 09:20–09:40

Model-free Adaptive Attitude Control for Combined Spacecraft with Input Saturation and Prescribed Performance

Huang, Xiuwei — Ji Hua Laboratory
Dong, Zhiyan — Fudan Univ.
Zhang, Feng — China Acad. of Launch Vehicle Tech.
Zhang, Lihua — Fudan Univ.

This paper develops a model-free adaptive attitude controller for combined spacecraft with prescribed performance under input saturation. Firstly, the attitude kinematics and dynamics of the combined spacecraft consists of a rigid service spacecraft, a rigid target spacecraft, and a rigid manipulator are introduced to generate input/output data. Then, a multi-input multi-output (MIMO) data model is established by the compact-form dynamical linearization (CFDL) method. Furthermore, a sliding mode function is used to construct a model-free adaptive controller with prescribed performance, containing an anti-windup compensator to compensate input saturation. Finally, the proposed approach is demonstrated through numerical simulation.

► FriA05-6 09:40–10:00

A Non-central Multi-Agent Routing Protocol of Self-organized Wireless Network for Missile Swarm Communication

Lu, Xiaodong — Northwestern Polytechnical Univ.
Wang, Chenzhao — Northwestern Polytechnical Univ.
Huo, Junxin — Northwestern Polytechnical Univ.
Wang, Wei — Northwestern Polytechnical Univ.

As the fast mobility of position and uncertainty of quantity in the missiles swarm, the flooding routing protocol which is widely used in the communication of self-organized wireless network has unsatisfied communication capability and intolerable energy consumption under the large number of communication nodes with complex topology. To overcome these deficiencies, this paper studied a non-central multi-agent routing protocol of self-organized network for missile swarm, which could provide random communication between multiple missiles in cooperative engagement. The proposed protocol regards each nodes as an agent with the capabilities of autonomous perception, independent decision-making and multihop communication. The agents receive the broadcast information with multihop lists from the neighbour nodes and build the reachability matrix with the multihop depth. Considering the optimization function with communication load and energy consumption of each node, the agents update the forwarding routing table iteratively under the agents' reachability matrix and right rotation rule. The mathematical simulation results showed that the proposed multi-agent routing protocol could effectively reduce the network load and the energy consumption of each node than the flooding routing protocol.

FriA06 08:00–10:00 Room 7

Regular Session: ILC and Adaptive Control

Chair: Li, Xuefang — National Univ. of Singapore
Co-Chair: Lu, Wenzhou — Jiangnan Univ.

► FriA06-1 08:00–08:20

The Second-Order 6k±1-Order Repetitive Control for Three-Phase Grid-connected Inverter

Lu, Wenzhou — Jiangnan Univ.
Hu, Licong — Jiangnan Univ.
Wang, Wei — Jilin Electric Power Co., Ltd., State Grid Corporation of China
Zhou, Keliang — Wuhan Univ. of Tech.
Lang, Yongbo — Jilin Electric Power Co., Ltd., State Grid Corporation of China
Zhang, Zhongbao — Jilin Electric Power Co., Ltd., State Grid Corporation of China

The conventional repetitive control (CRC) cannot obtain ideal control performance when a large number of renewable energy are connected to the new power system. In this paper, the second-order 6k±1 repetitive control (SO 6k±1 RC) which is composed of a standard structure of SO 6k±1 RC is proposed. The control performance can be improved comprehensively in the three-phase grid-connected inverters when the proposed SO 6k±1 RC is applied, include the steady-state performance, dynamic performance, and frequency self-adaptability. Since SO 6k±1 RC can update filter coefficient online at any one time, so good dynamic response and steady-state performance are obtained, and the problem of frequency variations can be solved effectively in the three-phase grid-connected inverters. Simulation results for the three-phase grid-connected inverters controlled by the proposed SO 6k±1 RC show that good frequency self-adaptability is obtained compared with CRC/6k±1 RC.

► FriA06-2 08:20–08:40

Autonomous Drone Racing: Spatial Iterative Learning Control Within A Virtual Tube

Lv, Shuli — Beihang Univ.
Yan, Gao — Beihang Univ.
Che, Jiaxing — Beihang Univ.
Quan, Quan — Beihang Univ.

It is often necessary for drones to complete delivery, reconnaissance, photography, and rescue in the shortest time to increase efficiency. Many autonomous drone races provide platforms to pursue algorithms to finish races as quickly as possible for the above purpose. Unfortunately, existing methods often fail to keep both training time and racing time short in drone racing competitions. This motivates us to develop a high-efficient learning method by imitating the training experience of top racing drivers. This paper first establishes a virtual tube replacing the autonomous drone racing scene and then proposes a data-driven online spatial iterative learning control approach. Unlike traditional iterative learning control methods for accurate tracking, the proposed approach iteratively learns a trajectory online to finish the race as quickly as possible. Simulations and experiments using different models show that the proposed approach is data-driven and is able to achieve the optimal result almost within a small number of iterations. Furthermore, this approach surpasses some state-of-the-art methods in racing time on a benchmark drone racing platform. A real experiment is also performed to demonstrate the effectiveness when the control law is implemented on a real quadcopter.

► FriA06-3 08:40–09:00

Adaptive Path Tracking Control for Autonomous Vehicles with Input Constraints and Actuator Faults

Li, Hongbo — Sun Yat-sen Univ.
Li, Xuefang — National Univ. of Singapore

In this work, an adaptive path tracking control approach for autonomous vehicle systems is proposed in presence of dynamical uncertainties, input saturation, and actuator failures. The unknown system characteristics are described as a coefficient matrix, which is estimated by utilizing an iterative learning algorithm. Furthermore, a fault-tolerant learning scheme is developed to deal with potential actuator failures caused by the vehicle loss or accidents. In addition, a saturation compensator is used to mitigate the negative effects of the actuator saturation. The adaptive path tracking controller is then designed by adopting the adaptive backstepping approach. The convergence of the proposed control method is analyzed by applying the composite energy function methodology, and its efficacy is demonstrated by using numerical simulation.

► FriA06-4 09:00–09:20

Discrete Fourier Transform Based Frequency Characteristics of PD-type Iterative Learning Control

Li, Xiaohui — Northwest A & F Univ.
Ruan, Xiaoe — Xi'an Jiaotong Univ.

For discrete-time iterative learning control systems, discrete Fourier transform (DFT) is a powerful technique for frequency analysis and Toeplitz matrix is a typical tool for the system input-output transmission. This paper exploits z-transform and DFT-based frequency properties for iterative learning control systems and studies convergence property for Toeplitz matrix to the power of iteration index. The exploitation exhibits that for the finite-length discrete-time iterative learning control systems, the time-domain convolution theorem for z-transform and DFT is no longer true and the Toeplitz matrix to the power of iteration index converges if and only if the identical diagonal element lies in unit circle. Then, by considering the DFT to a finite-length sequence as a linear transform, it is easy to equivalently reform the input-output equation of the linear discrete time-invariant and time-varying ILC systems as an algebraic discrete-frequency equation. Thus the proportional-derivative-type (PD-type) iterative learning control (ILC) is convergent in discrete-frequency domain if and only if it is convergent in discrete-time domain. Numerical simulations are carried out to exhibit the validity and the effectiveness.

► FriA06-5 09:20–09:40

Adaptive Iterative Learning Control for High-Speed Train Based on Multi-Agent Framework

Huang, Deqing — Southwest Jiaotong Univ.
Chen, Yong — Zhejiang Univ.

The precise tracking control of high-speed train is an essential prerequisite to ensure the safety and comfort of the train. In this paper, an adaptive iterative learning control (ILC) scheme for the velocity and displacement tracking of high-speed train is proposed to handle the unknown

time-varying parameters and lumped uncertainties. The composite energy function (CEF) method is used to analyze the stability of closed-loop system. Since the train usually runs on the same railway periodically, such as the same tunnels, slopes, and bridges, etc., ILC is an inherent method for designing the tracking controller that is able to improve the operation performance of train iteratively. Compared with the existing works, the proposed control approach can better reveal the coupled characteristic of adjacent cars and impose the repetitive operation pattern of train. The results of numerical simulations show that the tracking performance of the train towards the reference trajectory is significantly improved along with the increase of the number of operations.

▶ FriA06-6 09:40–10:00

On Finite-Iteration Convergence of Iterative Learning Control

Liu, Zhiqing — Qingdao Univ. of Sci. & Tech.
Chi, Ronghu — Qingdao Univ. of Sci. & Tech.
Liu, Yang — Guangdong Univ. of Tech.

n this paper, a new problem of finite-iteration convergence of iterative learning control is discussed for a linear time-varying system. Considering a PD-type learning law, the finite-iteration convergence is shown by introducing two-dimensional system theory under some assumptions. By solving a set of linear matrix inequalities, the two learning gains of the control law can be updated in real time to ensure that the tracking error converges to an arbitrarily specified bound within finite iterative operations. Simulation study illustrates the correctness of the theoretical results.

Poster Session FriA07
Aug. 5, 8:00–10:00
Emei Ballroom

Chair: Xiong, Wenjun — Southwestern Univ. of Finance & Economics
Co-Chair: Li, Sheng — Zhejiang Univ. of Tech.

▷ FriA07-01

An Approach to the Extraction of Intersecting Pipes Weld Seam Based on 3D Point Cloud

Yang, Shuai — Shandong Univ.
Shi, Xiaorui — SINOTRUK Jinan Power Co.,Ltd
Tian, Xincheng — Shandong Univ.
Liu, Yan — Shandong Univ.

In this paper, a method based on point cloud for weld seam extraction of intersecting pipes workpiece is proposed. Firstly, a lightweight clustering algorithm based on the normal vector direction was proposed to extract the feature points of the weld seam. After filtering the feature points, a novel key points extraction algorithm was proposed to extract the key points of the weld seam. After that, NURBS curve was used to approximate the key points and the preliminary spatial weld curve was obtained. Finally, an iterative algorithm was adopted to optimize the generated weld curve. The proposed method is verified on the ideal and real intersecting pipes point cloud models. Experiments show that the proposed method has high accuracy and robustness, and can accurately extract the intersecting pipes weld seam curve, providing guidance for the subsequent accurate automatic welding.

▷ FriA07-02

The Design of Robust Adaptive Controller Based on JITL Method for Nonlinear Process

Zhou, Liuming — Shanghai Univ.
Li, Feng — Jiangsu Univ. of Tech.

In this paper, a robust adaptive control strategy is presented based on just-in-time learning(JITL) method for nonlinear processes. The dynamic system model of the nonlinear process can be represented by a set of local linear models based on the JITL method, and the database of JITL model is updated according to current input and output. Considering the tracking error, we introduce a feed-forward compensation which is consists of proportional and integration link to the control system, and then we can obtain a robust PID controller based on uncertain local state-space models. As a result, the simulation results show that the proposed control system has good robustness and excellent real-time control performance, and it provides a new way for the control of nonlinear processes.

▷ FriA07-03

Data-Based Control Design for Learning Systems

Wu, Yuxin — Beihang Univ.
Meng, Deyuan — Beihang Univ. (BUAA)

This paper aims at presenting a data-based control design method for iterative learning control (ILC) systems such that the perfect tracking objective can be achieved without any model information. By only utilizing the input and output data collected in the test iterations, the trackability property of the given desired reference can be validated, which guarantees the existence of the desired input generating the desired reference for any ILC system with linear dynamics. Moreover, the idea of the observer design is leveraged to develop an ILC updating law only based on the collected input and output data. Thanks to the data-based ILC updating law, the perfect tracking objective is realized for ILC systems subject to any trackable desired reference despite the generally required full rank condition, where any knowledge of the model information is never needed.

▷ FriA07-04

Trajectory Tracking of Bus Based on Feedback-feedforward Model Free Adaptive Control

Ren, Ye — Beijing Jiaotong Univ.
Li, Siyuan — North China Univ. of Tech.
Wang, Li — North China Univ. of Tech.
Yin, Hao — North China Univ. of Tech.

In this paper, a feedback-feedforward trajectory tracking control method based on model-free adaptive iterative learning is proposed for bus that aiming the periodic repetitive work characteristics. First of all, considering the bus operation reality, the vehicle longitudinal kinematics model is established under repetitive environment. Secondly, the model free adaptive control (MFAC) is combined with feedforward iterative learning control (ILC) to realize the vehicle position tracking. Finally, the simulation analysis is carried out with selected bus parameters. The simulation results show that this control method can effectively utilize the historical data of the bus operation, and realize the high-precision tracking performance in the limited time range.

▷ FriA07-05

An Improved Multi-agent Model-free Adaptive Iterative Learning Consensus Control under Data Dropouts

Yan, Shuaiming — Big Data Acad., ZhongKe

Aiming at the problem of multi-agent consensus tracking under output data dropout, a model-free adaptive iterative learning control scheme for multi-agents, and a data compensation method are proposed. The phenomenon of data dropout is described as a Bernoulli sequence with the known probability, and a compensation algorithm for data dropout is proposed, that is, using the known output data, the estimated value of the pseudo gradient and the control input difference to compensate for the lost data. Then, the convergence analysis of the algorithm is given for the compensation algorithm proposed. The effectiveness and superiority of the algorithm is verified through the simulation of multi-agent system with the fixed topology.

▷ FriA07-06

Dynamic Modeling and Tracking Control of Underwater Snake Robot

Tao, Baosheng — Tianjin Univ. of Tech.
Sun, Hao — Nankai Univ.
Sun, Junqing — Tianjin Univ. of Tech.

This paper proposes a three-link underwater snake robot with propeller in the tail based on two-dimensional planar motion, which solves the problem of limited movement of underwater robot in narrow waters, rock crevices, underwater pipelines and other environments. In order to realize the stable control of underwater motion of three link underwater snake robot, the water resistance and water resistance torque of underwater snake robot are analyzed. The kinematics and dynamics models of planar underwater snake robot are established by using momentum theorem and momentum moment theorem. The stability and robustness of the two control strategies are analyzed through simulation experiments, and the results show that the control strategy based on ADRC is obviously better than PID control.

▷ FriA07-07

A PID Controller Based on ESO and Tuning Method

Li, Xiangyang — South China Uni. of Tech
Hu, Yu — Cleveland State Univ.
Gao, Zhiqiang — Cleveland State Univ.
Ai, Wei — South China Univ. of Tech.
Tian, Senping — South China Univ. of Tech.

PID (proportional-integral-derivative) is a widely used form of industrial control because of its simplicity and effectiveness. Its tuning, however, is usually tedious and experience dependent. In this paper, a more general form of PID, denoted as PIDn-1, is proposed as a variation of ADRC (active disturbance rejection control). In addition to dealing with high or-

der dynamics, the PIDn-1 has only three parameters (b0, ωo, and ωc) to tune, all of them have explicit physical meanings. This helps streamlining the controller tuning process and making PIDn-1 easy to use in industry. The experiments verify the effectiveness of the proposed PIDn-1 solution and the ease of tuning.

▷ FriA07-08

SMOTE-Based Fault Diagnosis Method for Unbalanced Samples

Xu, Yuan	Beijing Univ. of Chemical Tech.
Cheng, Xiaoqian	Beijing Univ. of Chemical Tech.
Ke, Wei	Macao Polytechnic Inst.
Zhu, Qunxiong	Beijing Univ. of Chemical Tech.
He, Yan-Lin	Beijing Univ. of Chemical Tech.
Zhang, Yang	Beijing Univ. of Chemical Tech.

Industrial processes are changing with each passing day, and the probability of failure is also increasing, and accurate fault diagnosis is becoming extremely important. In this paper, SMOTE-based fault diagnosis method for unbalanced samples is proposed. First, the SMOTE algorithm is used to oversample the unbalanced sample. Second, considering the high dimensionality of industrial data, the FDA algorithm is used for feature extraction. Third, the AdaBoost algorithm is used for fault diagnosis. Finally, the simulation validation is performed on the TFF dataset. The method proposed in this paper has higher diagnostic accuracy than other methods.

▷ FriA07-09

A Fault Prediction System for the Complex Satellite Management System Based on Rule and Fault Tree

Li, Ganhua	Xi'an Satellite Control Center
Fan, Henghai	Xi'an Satellite Control Center
Dong, Li	Xi'an Satellite Control Center
Li, Xianwu	Xi'an Satellite Control Center
Tai, Nengjian	Xi'an Satellite Control Center
Gao, Yaruixi	Xi'an Satellite Control Center
Zhang, Ruolan	Xi'an Satellite Control Center

An effective fault tree prediction method is presented in this paper based on the fault tree and the curve fitting, which is used for the complex satellite management system of Space Data Process Center (SDPC). At first, the framework of the prediction system is introduced for the software and the hardware monitor. Secondly, the visual inference method is presented based on fault tree and rule. Then prediction process is described step by step based on the curve fitting method and fault tree. At last, the prediction is realized and verified though the prediction system. After the really data application, the method could predict the fault of the computer, communication and server system. The predication system could predict the fault for the SDPC software system based on the multicast effectively, which could improve the stability of SDPC system.

▷ FriA07-10

IGBT Status Prediction Based on PSO-RF with Time-Frequency Domain Features

Wang, Yizhou	Southwest Jiaotong Univ., Chengdu
Xie, Fei	Southwest Jiaotong Univ.
Zhao, Tianwen	Southwest Jiaotong Univ.
Li, Zhuoran	Southwest Jiaotong Univ.
Li, Mingyue	Southwest Jiaotong Univ.
Liu, Dong	Southwest Jiaotong Univ.

The Insulated Gate Bipolar Transistor(IGBT) life prediction is technique that uses neural networks to predict the IGBT' s remaining useful life(RUL). Past studies have discussed the IGBT RUL prediction under different situations, where models based on Recurrent Neural Network(RNN), Back Propagation(BP) Neural Network and other structures have been widely used. With the IGBT aging dataset provided by NASA PcOE research center, this paper introduces a new approach to predict the IGBT life stage. The average accuracy of prediction based on time-domain features is 72.46%, and the one based on frequency domain features is 60.36%. By combining features in both time-domain and frequency domain and removing the features with few effect on prediction, the model has reached an average accuracy of 78.26%, with RMSE of 0.0619. After Particle Swarm Optimization, the average accuracy of the model increases to 86.96%, with RMSE of 0.0184. In the future, models with higher accuracy and lower RMSE may be used in industrial applications to detect IGBTs with short useful life, which can significantly increase the Mean Time Between Failure(MTBF).

▷ FriA07-11

Outlier Removal of Discontinuous Satellite Telemetry Data Based on Deconvolutional Reconstruction Network

Zhao, Haotian	Harbin Inst. of Tech.
Liu, Ming	Harbin Inst. of Tech.
Luo, Tianyi	Harbin Inst. of Tech.

Satellite telemetry data is very important strategic resource. We can monitor and predict the status of the satellite through analyzing the telemetry data. However, due to interference on the satellite and sensor failure, the telemetry data will jump and generate outliers. Therefore, it is necessary to identify and remove the outliers. This paper proposes an outlier removal method based on deconvolutional reconstruction networks. The deconvolutional reconstruction networks is composed of multiple convolution and deconvolution which is used to learn the internal laws from massive telemetry data. The learned network can make accurate predictions for normal data except for outliers. Our method use this difference to set the threshold and perform outlier removal. The deconvolutional reconstruction networks proposed in this paper uses a very few parameters for rapid learning. The networks can converge within 20 epochs for multiple sets of telemetry datasets which contains more than 60k discontinuous points. Numerical experiments show that the proposed method can achieve perfect removal effects.

▷ FriA07-12

Fault Diagnosis of Subway Sliding Plug Door Based on Machine Learning and Motor Current Signal

Huang, Jiaman	Southwest Jiaotong Univ.
Guo, Shenyuan	Southwest Jiaotong Univ.
Jiang, Jierui	SWJTU-Leeds Joint School Southwest Jiaotong Univ.
Shi, Fengjun	South West Jiao Tong Univ.
Wenxiu, Liu	Xihua Univ.
Liu, Dong	Southwest Jiaotong Univ.

With the rapid development of rail transit in our country, the subway has become one of the most important methods. As a guarantee for passenger safety, the reliability and safety of subway sliding doors have become a hot research object. However, due to the high frequency of use, long maintenance intervals, and complex structure, the probability of failure is high, and the safety of passengers and the normal operation of the vehicle cannot be guaranteed. The failure analysis and fault judgment of the sliding plug door of the system have important reference significance for the normal operation, debugging and maintenance of the sliding plug door. In this paper, the data processing method based on feature value extraction and the random forest algorithm are mainly used to judge the two types of faults " down-range pin" and " press wheel" . Compared with a single fault tree model, the use of eigenvalues in this study reduces the amount of data processing, emphasizes the differences of different data groups, and facilitates subsequent fault classification. And the random forest model, which can handle a large number of high-dimensional features, making the obtained results more accurate and reliable. The case analysis shows that our method can compensate for the one-sidedness of the results obtained due to the singleness of the fault tree model logic, and provide a reference for achieving high-accuracy fault judgment.

▷ FriA07-13

Iterative learning control of a class of complex valued systems described by Schr¨odinger equation

Cai, Liuchi	Guangxi Univ. of Sci. & Tech.
Dai, Xisheng	Guangxi Univ. of Sci. & Tech.,
Zhang, Jianxiang	Jiangnan Univ.
Zuo, Huang	Guangxi Univ. of Sci. & Tech.
Zhang, Jiaming	Guangxi Univ. of Sci. & Tech.

In this paper, boundary tracking control for a class of complex valued systems described by Schr¨odinger equation (SE) is solved by using iterative learning control (ILC). The control is imposed on the boundary x = 1. Since SE is a complex-valued, this leads to transforming the original equation into two coupled real-valued equations at first. Moreover, a complex P-type iterative learning control algorithm is designed and the convergence analysis is derived rigorously based on the contraction mapping methodology. The result of this paper show the actual output of the system will converge to the given desired output as the number of iterations tends to infinity under some given conditions.

▷ FriA07-14

Quantized Iterative Learning Control for Nonlinear Switched Discrete-time Systems with Actuator Saturation

Sun, Shu-Ting	Sun Yat-sen Univ.

Li, Xiao-Dong Sun Yat-sen Univ.

A quantized iterative learning control (ILC) scheme is investigated for nonlinear switched discrete-time systems with actuator saturation in repetitive operations. The logarithmic quantizers are utilized to quantize the tracking error signals, and the sector bound method is applied for analysis and mitigation of quantization influence. By using mathematical induction method, it is strictly proved that the tracking error of each subsystem will converge to zero with the increase of iteration. A numerical example is given to illustrate the validity of the quantized ILC algorithm.

▷ FriA07-15

Modeling and Characteristics of Smart Library Knowledge Ecosystem Structure Modeling and Characteristics Based on Super-network

Wei, Qiongqiong Qingdao Univ. of Sci. & Tech.

Super-network theory is used as a tool in this paper to construct a hierarchical structure of the smart library knowledge ecosystem network topology model. Through the analysis of the super-network topology characteristics of the model, this paper defines the key node identification of the smart library knowledge ecosystem and the system anti-destruction ability of the two key indicators. Then, we put forward the application concept of the smart library knowledge ecosystem super-network model.

▷ FriA07-16

Segmented Adaptive Singular Value Decomposition for Data Compression of IGBT

Qian, Jin Southwest Jiaotong Univ.

As Insulated Gate Bipolar Transistor (IGBT) is widely used in industrial practice, a compression algorithm based on two-dimensional block adaptive threshold singular value decomposition is proposed to solve the problem of storing massive data when IGBT is switched on. In order to more effectively improve the compression ratio and reduce the error of data, this method is to arrange the set of one-dimensional IGBT data into two-dimensional matrix normalizing to form two-dimensional gray image processing according to each part of the image characteristic of regional block. After adjustment by adaptively presetting threshold characteristic values of singular values, we use compression sensing to complete data compression. Multiple sets of original data can not only ensure the mean square error, but also meet the requirements of high compression ratio, high precision and low distortion, which significantly reduces the amount of data stored. The experimental results show that when the mean square error is about 0.05% and the mean absolute error is about 0.015, the compression ratio of 3% and the signal-to-noise ratio of 41.5dB can be achieved, which verifies the feasibility of the algorithm and has certain practical value.

▷ FriA07-17

Prediction of Photovoltaic Power Generation Based on D-vine Copula Model in Typical Climates

Zhang, Ruiyin Shanghai Univ.
Jia, Li Shanghai Univ.
Zhou, Yang Shanghai Univ.

Multi-dimensional climate factors like irradiation and humidity will lead to strong randomness of photovoltaic power generation, and it is difficult to consider all climate factors in traditional photovoltaic power generation point forecasting. Vine copula can accurately and flexibly describe the dependencies between multi-dimensional variables, establish conditional distribution expressions between photovoltaic power generation and multi-dimensional climate factors, and improve prediction accuracy. This paper proposes a D-vine copula model under typical climatic conditions. The model uses fuzzy C-means (FCM) to complete typical climate clustering, and then proposes a D-vine copula model to achieve point predictions and probability interval predictions. The results of the example show that the model has a good performance in point predictions and provide corresponding probability interval predictions, which proves the accuracy and applicability of the model.

▷ FriA07-18

Improved Path Planning Algorithm Based on RRT Algorithm and Quintic B-spline Curve

Zhao, Duo Southwest Jiaotong Univ.
Huang, Wendong Southwest Jiaotong Univ.

Aiming at the problems of strong randomness, unsmooth path and local optimum in the path planning of the Rapidly-exploring Random Trees (RRT) algorithm. The paper designs an improved RRT algorithm with variable step size and goal orientation (VO-RRT), which introduces variable step size, oriented expansion node, optimized initial path and smoothed path four parts. Through several experiments in 2D and 3D space to prove that the VO-RRT algorithm has enhanced obstacle avoidance ability and improved path smoothness in different obstacle spaces. The path nodes generated by the VO-RRT algorithm in 3D space are tested in URsim simulation software and manipulator body to verify the executability of the optimized path.

▷ FriA07-19

Multi-robot Task Allocation and Rescue for Mowing

Liu, Tengqian Southwest Jiaotong Univ.
Sun, Yongkui Southwest Jiaotong Univ.
Song, Weihong Southwest Jiaotong Univ.
Ma, Lei Southwest Jiaotong Univ.

Multi-mowing robots have an advantage over a single robot for a large mowing task. The task allocation of the multi-mowing robots' system needs to solve several problems, such as minimizing mowing time, minimizing duplicate areas, etc. In particular, when one or more mowing robots break down in the multi-mowing robot' s system, the uncompleted tasks need to be allocated again. The two algorithms to solve the task allocation are presented in this paper. One is the multi-mowing robots task allocation(MMRTA) algorithm based on the modified genetic algorithm, the other is the filling rescue algorithm. The task allocation was simulated with 4-32 robots to mow the grass field divided into 64 task blocks. The simulation result shows that the tasks and paths of each mowing robot are approximately equal, and proves that the task allocation algorithm proposed in this paper is feasible and effective. The filling rescue algorithm is simulated with 4 or 8 robots that surround the breakdown robot to complete the unfinished tasks of the breakdown robot. The simulation result testifies that the remaining tasks of the breakdown robot are reasonably and efficiently allocated.

▷ FriA07-20

A Robot Relocalization Method Based on Laser and Visual Features

Wang, Enhao Southwest Jiaotong Univ.
Chen, Dewang Southwest Jiaotong Univ.
Fu, Tianqi Southwest Jiaotong Univ.
Ma, Lei Southwest Jiaotong Univ.

Relocalization is a well-known problem to regain the robot's pose in an incorrect pose. Lidar localization is prone to drift and challenging to achieve relocalization, especially in environments with simple and repetitive geometric features. Image can obtain more texture information and color information than laser, which determines that the camera is more accessible to relocalization than the lidar. This paper proposes a fast and reliable relocalization method to solve the problem of laser localization drift and kidnapped robot by visual information. The robot can build and save the point cloud map and the grid map and calculate the correspondence. Relocalization is achieved through a relocalization trigger mechanism and Oriented FAST and Rotated BRIEF(ORB) feature points. Finally, Several experiments in the simulation and indoor environment were performed to verify the effectiveness of the proposed approach. The experimental results show that the relocalization recovery time of the proposed method is within two seconds. Compared with the relocalization achieved by lidar alone, the proposed method is three times faster.

▷ FriA07-21

A Neural Network with Spatial Attention for Pixel-Level Crack Detection on Concrete Bridges

Ji, Wenpeng Northwestern Polytechnical Univ.
Zhang, Yizhai Northwestern Polytechnical Univ.
Huang, Panfeng Northwestern Polytechnical Univ.
Yan, Yuchen Northwestern Polytechnical Univ.
Yang, Qilei Northwestern Polytechnical Univ.

Concrete bridges play a very important role in transportation. As the main type of concrete bridges' damage, crack detection is of great significance to ensure the safety of bridges. In order to avoid the influence of subjective factors, methods based on deep learning develop rapidly. In this paper, a new network model in the form of encoder-decoder is proposed. It achieves the crack detection on pixel-level, which means that the detection results can be further quantified in the future. Meanwhile, the model proposed adds Spatial Attention to take advantage of crack' s spatial characteristics. By doing this, more crack details can be found in the test results.

▷ FriA07-22

COVID-19 Detection in CXR Image Using High Frequency Emphasis Filtering Based Convolutional Neural Network

Ji, Honghai	North China Univ. of Tech.
Li, Jiaqi	North China Univ. of Tech.
Wang, Li	North China Univ. of Tech.
Fan, Lingling	Beijing Information Sci. & Tech. Univ.
Zhang, Yixiao	Beijing Shiny Tech.Co.,Ltd
Wang, Wei	PowerChina South Construction Investment CO.,LTD

As a huge disaster for humanity, the COVID-19 has caused many negative effects on the lives of people around the world with a rapid growth. Moreover, the global pandemic of Neocoronavirushas produced many mutated strains. Although the most commonly used test for COVID-19 is reverse transcription-polymerase chain reaction (RT-PCR), CXR becomes an irreplaceable tool for the diagnosis and analysis for a more complete and accurate visualization of the lung lesion process.Therefore, it is of high value for classification and identification studies. In this paper, the high-frequency emphasis filteringbased convolutional neural networks (HFEF-CNN) are proposed for solving the automatic detection of COVID-19. Firstly, the HFEF is used to denoise the image data to make some features in the image more obvious. Then some major CNNs are used to train image classification models to achieve better detection performance. Finally, Some experiments are conducted on the "COVID-19 Chest X-Ray Database" dataset.To verify the effectiveness of the HFEF-CNN, a histogram equalization based CNN (HE-CNN) and a restricted contrast adaptive histogram equalization based CNN (CLAHE-CNN) are compared. The experimental results show that the HFEF-CNN outperformed the above two methods.

▷ FriA07-23

Thermal Comfort Modeling of Office Buildings Based on Improved Random Forest Algorithm

Zhang, Hongchao	Univ. of Sci. & Tech. Beijing
Yang, Xu	Univ. of Sci. & Tech. Beijing
Tu, Rang	Univ. of Sci. & Tech.
Huang, Jian	Univ. of Sci. & Tech. Beijing
Li, Yiran	Univ. of Sci. & Tech. Beijing

HVAC systems usually regulate the thermal comfort of the building environment according to standards. However, residents living in different climatic conditions have different thermal preferences, unified standards for HVAC regulation may cause cold and thermal discomfort of indoor personnel and lead to excessive energy consumption. In order to analyze the thermal comfort of indoor personnel more accurately, this paper proposed an indoor thermal comfort model of office buildings based on an improved random forest algorithm. First, by using the data from a building environment smart monitoring system in an office environment, the thermal comfort is evaluated by experimenters in a variety of thermal environments. Then, based on the experimental results, the K-means algorithm is used to select the decision tree with low similarity, to form a new random forest, which has higher prediction accuracy for the test set. Finally, our proposed model is embedded in the smart monitoring system to verify its advantages and effectiveness. The experimental results show that the model is suitable for describing the thermal comfort of personnel in office space, which has higher precision and good generalization ability and can be further deployed to the HVAC system.

▷ FriA07-24

Adaptive Gaussian Process Regression-Based Remaining Useful Life Prediction of PEMFC Incorporating An Improved Health Indicator

Tang, Lin	Univ. of Sci. & Tech. Beijing
Yang, Xu	Univ. of Sci. & Tech. Beijing
Gao, Jingjing	Univ. of Sci. & Tech. Beijing
Huang, Jian	Univ. of Sci. & Tech. Beijing
Cui, Jiarui	Univ. of Sci. & Tech. Beijing

Considering the importance of the proton exchange membrane fuel cells(PEMFC) to daily life and industry, this paper makes the remaining useful life(RUL) prediction of the PEMFC based on two different environments. To this end, the improved health indicator is proposed to describe the health state of PEMFC. On this basis, a data-driven method, namely the adaptive Gaussian process regression(GPR) method, is proposed to predict the RUL of PEMFC. The effectiveness of the proposed life prediction method is demonstrated in the aging data set of PEMFC provided by the prognostic and health management(PHM) challenge by a case study, the artificial neural network(ANN) method, and the adaptive GPR method are used to predict the PEMFC's RUL. Results show that the adaptive GPR method achieves better prediction results and provides the probability distribution of the results compared with the ANN method.

▷ FriA07-25

Event -Triggered Adaptive Control for Underactuated Surface Vessels

Wang, Qiwen	ShanDong JiaoTong Univ.
Meng, Xiangfei	Shandong Jiaotong Univ.
Zhang, Qiang	Shandong Jiaotong Univ.
Wu, Hengtao	ShanDong JiaoTong Univ.
Wang, Caifan	ShanDong JiaoTong Univ.
Li, Xiaobo	ShanDong JiaoTong Univ.

This paper develops a depth information robust adaptive control algorithm with event triggered input for underactuated surface vessels with dynamic uncertainty and limited communication resources.The controller uses radial basis function (RBF) neural networks to approximate the model uncertainty.This paper designs an event triggered input because of the limited communication resources.The stability of the depth information robust adaptive control is rigorously proved via Lyapunov analysis.In comparing with the finite time control scheme without event-triggered and adaptive ANNs control scheme with minimum learning parameters(MLPs) and artificial neural network(ANNs), the event-triggered method can obtain better control effect.

▷ FriA07-26

A Novel YOLOv5-based Anomalous Object Detection Algorithm in Buses

Liu, Shida	Beijing Jiaotong Univ.
Li, Qingyi	North China Univ. of Tech.
Ji, Honghai	North China Univ. of Tech.
Wang, Li	North China Univ. of Tech.
Zhang, Xiaoping	North China Univ. of Tech.
He, Zhonghe	North China Univ. of Tech.

In this work, a novel abnormal objects analyzing and detecting (AOAD) algorithm inside the bus is proposed, and the AOAD algorithm is further applied to the practical bus by designing an embedded video analysis system. The proposed algorithm is based on the deep learning YOLOv5 (You Only Look Once) algorithm, which has better timeliness and accuracy in detecting anomalous objects. The anomalous objects with larger boxes are detected by building an anomalous object dataset for training. The effectiveness and applicability of the proposed algorithm is verified by extensive experiments on video data based on real buses.

▷ FriA07-27

Double-Net DDPG with the Optimal Action Selection Mechanism

Li, Dazi	Beijing Univ. of Chemical Tech.
Dong, Caibo	Beijing Univ. of Chemical Tech.

Recently, the deep reinforcement learning method based on actor-critic has a competent performance in continuous action control tasks, such as the proposed deep deterministic policy gradient (DDPG) algorithm. However, this algorithm also has its shortcomings in applications. For example, the actor network and the critic network are closely dependent, and the critic network is always prone to overestimation. Those may lead to poor updates of the policy. Different from the conventional double networks taking the smallest operation, different target actor networks are applied to generate actions when the critic network is updated. Considering the structure of the double networks, a better action is preferred, which is conducive to speeding up the network convergence. In this paper, the Double-Net DDPG algorithm with double actor networks and double critic networks is proposed, with the optimal action selection mechanism. It reduces the network dependency in DDPG. The result shows the proposed algorithm has improved the original algorithm and achieves excellent performance in the continuous action control task.

▷ FriA07-28

Optimal Tracking Control of Vehicle Cooperative Platoon Based on Reinforcement Learning

Li, Changcheng	North China Univ. of Tech.

This paper proposed a data-driven reinforcement learning control method to achieve optimal control of trajectory tracking for the centralized connected vehicle platoon model. It minimized distance and velocity error and improved fuel efficiency, where autonomous vehicles transmit and receive each other's vehicle status data via wireless vehicle-to-vehicle (V2V) communication device. Adaptive dynamic programming techniques are used to obtain optimal tracking control strategy in the presence of unknown system dynamics. The effectiveness of the proposed method is verified by an online learning control simulation of connected vehicles.

▷ FriA07-29

Low-dimensional Non-linear Luenberger Observer for Thermal Distribution of Wafer in Rapid Thermal Processing Process

Xiao, Tengfei Sun Yat-Sen Univ.
Kong, Ying Sun Yat-sen Univ.
Li, Xiao-Dong Sun Yat-sen Univ.

A low-dimensional non-linear observer is developed in this paper for the estimation of the thermal distribution in a rapid thermal processing (RTP) process. Based on the reduced model obtained from Galerkin's method, a low-dimensional non-linear Luenberger observer is designed to re-construct the thermal distribution from the output data of the point temperature sensors. Test results in a RTP system show fast convergence speed and small estimated errors of the proposed observer.

▷ FriA07-30

Research on Text Data Mining Method of Streaming Media Platform

Chen, Siwei Southwestern Univ. of Finance & Economics
Xiong, Wenjun Southwestern Univ. of Finance & Economics

With the rapid development of streaming media platforms, users prefer to express their preferences and thoughts in comments.Text analysis can further improve the product and service capabilities of the platform, but the traditional topic model LDA is not suitable for short or medium texts such as comments.This article crawls 28,370 comments on the video "The Most Beautiful Night in 2019" on bilibili, and first conducts sentiment analysis experiments to compare the accuracy of seven models in three types of methods.Then, BERTopic was used to process the classified positive and negative emotional texts. The new dimension reduction model Umap was used to make the model more suitable for clustering short and medium texts such as comments, and the positive and negative themes in comments were visualized more intuitively according to c-TF-IDF scores.Finally, this paper uses a social network model to show the connections and weights between nodes. On the basis of these analyses, it provides certain technical support for optimizing video production, hot event management and user portraits

▷ FriA07-31

A Matrix Software Library Method for the Ground System of Space Data Center

Li, Ganhua Xi'an Satellite Control Center
Fan, Henghai Xi'an Satellite Control Center
Dong, Li Xi'an Satellite Control Center
Han, Minzhang Xi'an Satellite Control Center
Kong, Bo Xi'an Satellite Control Center
Zhang, Ruolan Xi'an Satellite Control Center

A matrix software library is presented to rapidly establish the ground complex system of the Space Data Center， which is designed for the management of several hundred satellites. Firstly, the research of domestic and foreign study is analyzed. Secondly, the four-layer structure is introduced for Space Data Center system based on virtualized cloud computation that could divide the software with the hardware and the application effectively. Thirdly, the centralized hardware platform architecture is designed to decouple the operation with hardware, and the micro module Server room is used to manage the system efficiently. And then, the matrix software library method is presented based on the classification of the complex software system, and the rapid establishment process is introduced step by step for the management system of large number of satellites, which could load and unload the system on demand. This method could solve the problem of the multi-series and great number required by the satellite management for Space Data Processing Center. The system cost of the management and development is reduced effectively and efficiently. And the system operation and maintenance are reduced obviously.

▷ FriA07-32

Deep Learning Based Closed-loop Identification of Typical Thermal Process Model

Weng, Fanglong China Ship Development & Design Center
Zhang, Xin Southeast Univ.
Xue, Yali Tsinghua Univ.
Sun, Li Southeast Univ., Http://power.seu.edu.cn/sl/list.htm

Typical thermal process is generally of monotone response and can be well characterized by the first-order plus dead time (FOPDT) model. Therefore, system identification of FOPDT is of major interest in the field of thermal process control, including coal-fired power plants and gas turbines. However, the step response based open-loop experiment is sometimes not available due to the limitation of field operation, which necessitates the development of the closed-loop identification. This paper will employ artificial intelligence to derive a new method for closed-loop identification. Consequently, this paper, for the first time, uses a convolutional neural network (CNN) to identify the operation characteristics of devices in the closed-loop condition. The empirical results show that the application of CNN dramatically improves identification accuracy. When the size of training datasets reaches 50,000, the identification accuracy of this method was higher than 98%.

▷ FriA07-33

Communication-Efficient Federated Learning with An Event-Triggering Strategy

Li, Yuhao Beihang
Bai, Junxiang Beihang Univ.
Li, Duo Beihang Univ.
Li, Wenling Beihang Univ.

With the development of artificial intelligence, data has become one of the most important resources. However, the emphasis on data privacy by countries in the world has brought great obstacles to the further development of artificial intelligence. Federated learning keeps the local data set from being exposed to the outside world by passing model parameters during the training process, so communication cost has become a major bottleneck in the training process of federated learning. In this paper, to reduce useless communication during parameter upload, we propose a new federated learning algorithm with an event-triggering strategy based on model performance. Through this strategy, a certain number of communication times have been reduced, so as to reduce the communication cost in training. In order to verify the performance of the algorithm, we carried out experiments on MNIST. The experimental results show that our algorithm can reduce the communication cost by 38% at the same level of accuracy compared with the federated average. At the same time, compared with other event-triggering strategies, it can have less communication times at the same level of accuracy.

FriB01 10:10–12:10 Room 1

Invited Session: Data-Based Learning and Control

Organizer: Hui, Yu Beihang Univ. (BUAA)
Organizer: Lu, Changxin Beihang Univ.
Organizer: Meng, Deyuan Beihang Univ. (BUAA)
Organizer: Chi, Ronghu Qingdao Univ. of Sci. & Tech.
Chair: Hui, Yu Beihang Univ. (BUAA)
Co-Chair: Lu, Changxin Beihang Univ.

▶ FriB01-1 10:10–10:30

A Multi-stage Optimized Fault Diagnosis Model for Imbalanced Fault Data in Manufacturing Process

Lai, Zhouhao Guangdong Univ. of Tech.
Dong, Yan Guangdong Univ. of Tech.
Ren, Hongru Guangdong Univ. of Tech.
Lu, Renquan Guangdong Univ. of Tech.

Fault diagnosis of equipment in the manufacturing process is particularly important, and it is an indispensable link in intelligent manufacturing. The fault data generated by the equipment during the manufacturing process is often imbalanced. However, modeling and training on imbalanced dataset will result in a very high rate of misclassification. In order to solve this problem, and improve the accuracy of fault diagnosis in the manufacturing process. This paper proposes a multi-stage optimizatied fault diagnosis model based on bayesian optimization, synthetic minority oversampling technique(SMOTE) and stagewise additive modeling using a multi-class exponential loss function(SAMME), namely the BSS model. The multi-stage optimized fault diagnosis model proposed in this paper improves the diagnosis accuracy of imbalanced fault dataset from the aspects of dataset processing, model building and model training. Finally, the results of ultrasonic flowmeter failure diagnosis show that among the various evaluation indicators, the multi-stage optimized fault diagnosis model proposed in this paper is better than the traditional single machine learning model.

▶ FriB01-2 10:30–10:50

An Automatic Approach for Aircraft Landing Process Based on Iterative Learning Control

Cui, Shunfeng Soochow Univ.
Chen, Yiyang Soochow Univ.
Tao, Hong-Feng Jiangnan Univ.

The aircraft landing process is the most complicated flight phase, and it is also the most prone to flight accidents. Completing a safe landing process puts high demands on the pilot's skills, which makes the cost of training an outstanding pilot rather expensive. The aircraft dynamics and kinematics model consist of nonlinear, highly coupled, multi-complexity equations. A large number of state data transformations will be gen-

erated during the flight, and there are very strict requirements on the timeliness and accuracy of data analysis and processing. In this paper, the authors take the advantage of iterative learning control methodology to propose a optimization algorithm based on gradient to solve the tracking problem of a given aircraft landing trajectory. The simulation results indicate that applying this new algorithm is able to gradually make the error of flight path converge to zero. Compared with traditional control methods, this iterative learning control algorithm has more excellent performance in terms of accuracy.

► FriB01-3 10:50–11:10
Secure and Privacy-Preserving Consensus for Multi-Agent Networks under Deception Attacks

Hu, Qinling — Hangzhou Dianzi Univ.
Wu, Yiming — Hangzhou Dianzi Univ.
Zheng, Ning — Hangzhou Dianzi Univ.
Xu, Ming — Hangzhou Dianzi Univ.
He, Xiongxiong — Zhejiang Univ. of Tech.

This paper studies the distributed consensus problem for discrete-time multi-agent networks under deception attacks. For the privacy of agent initial state value, an additive secret sharing method is adopted at the initial time of the system. To overcome the adversarial effects of deception attacks on the network, a distributed secure method is used to identify and remove the tampered values from the attacks, and then a control protocol is designed so that all normal nodes in the network are able to converge to the average value of the initial values. Theoretical analysis shows that the proposed method can effectively resist the impact of deception attacks and achieve the accurate average consensus of the system. Numerical examples are also given to demonstrate the effectiveness of the results.

► FriB01-4 11:10–11:30
Iterative Dynamic Internal Model Based ILC for A Class of Nonlinear Nonaffine Discrete-time Systems

Zhuang, Yongbo — Qingdao Port International Co., Ltd
Zhang, Huimin — Qingdao Univ. of Sci. & Tech.
Chi, Ronghu — Qingdao Univ. of Sci. & Tech.
Wen, Hongjie — Qingdao Port International Co., Ltd

In this work, a new iterative dynamical internal model control approach (IDIMC) is presented for a nonlinear nonaffine discrete-time system with uncertainties. The CFDL-based iterative linear data model (ILDM) with one unknown parameter is used as a internal model to estimate the nonlinear process. The IDIMC consists of two parts: an iterative nominal control law designed to enable the system output track the reference trajectory perfectly, an iterative uncertainty compensation control law designed to compensate the negative effects caused by the external disturbances. The simulation study verifies the effectiveness of the proposed methods.

► FriB01-5 11:30–11:50
Anomaly Detection Method Based on Sample Constrained Training

Tian, Ying — Bohai Univ.

According to the problems of the iForest algorithm which may cause the poor accuracy and efficiency by selecting root node samples and cutting points randomly, an anomaly detection algorithm named SCT-iTree is presented based on sample constrained training. In this algorithm. Firstly, the distribution form is considered when the training data set is extracted, which makes sure the training data has the same distribution with the original data set. Secondly, the split attribute is chosen according to the information entropy of the current sample data when the SCT-iTree is formed. Thirdly, the center of gravity of particle system is adopted to solve the split point of the attribute when selected the split point to make the point at the end where the data points are sparse. Through the constraints of the above three stages, the quality of the training tree is improved. The simulations shown that the SCT-iForest can improve iForest and LOF in aspects of detection quality and running speed of anomaly detection by preprocessing the sample data, which can obtain the higher quality training sample sets for isolate the outlier data. Especially, this algorithm has better stability than iForest for data sets with moderate amount of data and high dimensional data with large proportion of abnormal data.

► FriB01-6 11:50–12:10
Neural Network Based Adaptive Consensus Control for A Class of Nonlinear Multi-Agent Systems with Time Delays

Wang, Zuo — Huaqiao Univ.
Chen, Liheng — Harbin Engineering Univ.
Zhu, Yanzheng — Huaqiao Univ.

This paper studies the tracking consensus control issue for a class of time-delay multi-agent systems. The nonlinear functions usually exist in the practical systems, which can be handled by using the neural networks technique. Then, on account of the Lyapunov stability theorem and Lyapunov-Krasovskii functions, it verifies that the tracking consensus errors are semi-globally uniformly ultimately bounded. Finally, the feasibility and effectiveness of the proposed method are verified by a numerical example.

FriB02 10:10–12:10 Room 3
Invited Session: Intelligent Control for Complex Nonlinear Systems

Organizer: Liang, Hongjing — College of Engineering, Bohai Univ.
Organizer: Liu, Yang — Guangdong Univ. of Tech.
Chair: Liang, Hongjing — College of Engineering, Bohai Univ.
Co-Chair: Liu, Yang — Guangdong Univ. of Tech.

► FriB02-1 10:10–10:30
A Quality Prediction Hybrid Model of Manufacturing Process Based on Genetic Programming

Peng, Chong — Guangdong Univ. of Tech.
Cheng, Zhijian — Univ. of Sci. & Tech. of China
Ren, Hongru — Guangdong Univ. of Tech.
Lu, Renquan — Guangdong Univ. of Tech.

The design of manufacturing parameters in the initial stage is backed by quality prediction to realise intelligent manufacturing. Accurate prediction translates to better quality, lower costs and more flexibility. However, the real production is a complicated and variable process, most of which involved multiple parameters simultaneously. The data on the basis of feature construction can filter the impurities of data, accuracy of predictive model can be satisfied. Existing approaches to provide results are useless when the insufficient mining of the relationship between the data or the some case without adequate manufacturing data and expertise. In this paper, a two-stage hybrid approach with genetic programming is proposed for quality prediction. The feature construction is realized by genetic programming in the first stage, and the new features are utilized as additives to subsequent stage of the extreme gradient boosting. The comparison experiments indicate that the two-stage hybrid model outperforms the existing methods in overall performance.

► FriB02-2 10:30–10:50
Zero-Sum Game for A Class of Second-Order Systems

Ji, Weiyu — Bohai Univ.
Pan, Yingnan — Bohai Univ.
Zhou, Xiaoshuai — Bohai Univ.

This paper studies the zero-sum game problem for second-order strict-feedback nonlinear systems. By using the simplified reinforcement learning algorithm, the solution of Hamilton-Jacobi-Isaacs equation can be achieved. Based on the Lyapunov functional method, the proposed control scheme ensured that the system output signal can follow the given desired signal, and it is proved that the tracking error can converge to a small area near zero and all signals of the closed-loop system are semi-globally uniformly ultimately bounded. Finally, a simulation example is provided to testify the validity of the control strategy.

► FriB02-3 10:50–11:10
An Optimal Sliding Mode Controller Against False Data Injection Attacks

Wu, Chengwei — Harbin Inst. of Tech.
Dong, Bo — The Second Acad. of CASIC
Han, Shuo — Harbin Inst. of Tech.
Yao, Weiran — Harbin Inst. of Tech.

This paper investigates the optimal discrete sliding mode control problem of cyber-physical systems, actuators of which are intercepted by false data injection attacks. Although false data injection attacks can be regarded as matched input uncertainties, some existing sliding mode control schemes cannot be directly applied since attacks may not satisfy some properties of uncertainties, for example, the smoothness condition. In the design process, the linear quadratic optimal control is combined to design an optimal sliding mode surface, based on which an optimal discrete-time sliding mode controller is derived by using a modified Gao's reaching law. To implement such a control scheme, an estimator is introduced to estimate false data injection attacks. Finally, a numerical example is given to validate the effectiveness of the proposed secure controller.

► FriB02-4 11:10–11:30
State-dependent Event Triggered Path Following Control of Unmanned Ground Vehicle with Uncertainties

Zhang, Pengfei Qufu Normal Univ.
Sun, Hongtao Qufu Normal Univ.
Chen, Ziran Nanjing Univ. of Sci. & Tech.
Tan, Cheng Shandong Univ.

Event-triggered communication (ETC) is a very important scheme to save more limited network resources, while preserving the desired control performance. However, due to the controlled system become more and more complicated, especially there are exist some uncertain parameters in state. This motivates us to investigate a state-dependent event-triggered communication (SD-ETC) to solve the problem of path tracking control of unmanned ground vehicle (UGV). Then, an event-triggered H_∞ controller is designed, which based on state adjustment scheme and combined with the time-delay system modeling method, Lyapunov stability theory. Compared with the existing static ETC, the SD-ETC can dynamically adjust event-triggered threshold based on the real-time state detection of the path tracking control system. The effectiveness of the proposed SD-ETC is verified by Matlab simulation experiments.

▶ FriB02-5 11:30–11:50

Bipartite Consensus Tracking for Stochastic Multi-Agent Systems: A Finite-Time Prescribed Performance Approach

Chen, Lei Bohai Univ.
Hong, Xue Bohai Univ.

This paper focuses on the bipartite consensus tracking problem for stochastic nonlinear multi-agent systems (MASs). The finite-time prescribed performance control approach is integrated into the design of the controller to ensure that MASs complete bipartite consensus tracking missions with a predetermined accuracy in a predetermined time. In addition, utilizing the approximation ability of neural networks, the unknown nonlinear dynamics in MASs are resolved. Then, based on the stochastic Lyapunov stability theory, it is proved that all signals of MASs are semi-global uniformly ultimately bounded in probability, and MASs complete bipartite consensus tracking missions with desired performance. Finally, the simulation results verify the effectiveness of the designed controller.

▶ FriB02-6 11:50–12:10

Fault Detection for T-S Fuzzy Systems with Local Nonlinear Model

Li, Shaoyi Nanchang Inst. of Sci. & Tech.
Wei, Yanping Nanchang Inst. of Sci. & Tech.

The fault detection (FD) problem for T-S fuzzy systems with local nonlinear models is considered in this paper.Firstly, nonlinear systems are approximated by fuzzy systems with local nonlinear models. Then, an unknown input observer is established to diagnose the fault where the estimation error of local nonlinear model is decoupled. Secondly, an L∞/H performance index is considered in the design to decrease robustness of the external disturbance and increase the sensitivity of the fault. Then, the synthesis conditions of the observer are obtained. Finally, a numerical example is given to show the efficacy of the developed FD scheme.

FriB03 10:10–12:10 Room 4

Regular Session: Data Driven Control (II)

Chair: Pang, Zhonghua North China Univ. of Tech.
Co-Chair: Song, Yang Shanghai Univ.

▶ FriB03-1 10:10–10:30

IGBT Massive Data Compression Based on the Adaptive Threshold Wavelet Compression Algorithm

An, Boning Southwest Jiaotong Univ.
Tian, Xiao Southwest Jiaotong Univ.
Wang, Jialong Southwest Jiaotong Univ.
Sui, Zhouli SWJTU-LEEDS Joint School
Li, Mingyue Southwest Jiaotong Univ.
Liu, Dong Southwest Jiaotong Univ.

An adaptive threshold wavelet compression algorithm is proposed to solve the problem that too much aging data is difficult to process and store in IGBT fault diagnosis. This method takes the IGBT switching process is a cycle, to arrange more groups of raw data into two-dimensional matrix, after normalization treatment into two-dimensional gray image, then according to the compression ratio to do the self-adaption block processing, by adjusting the magnification and compression ratio using two-dimensional wavelet transform and get the two-dimensional wavelet coefficient, complete the data compression. This method not only ensures the compression rate, but also satisfies the data precision and reduces the localized distortion rate, and saves the disk space occupied by IGBT data to a great extent. If the aging data is not compressed, hundreds of gigabytes or terabytes of data will be generated every day, which greatly affects the performance of the computer and occupies a large amount of storage space in the system. Taking NASA IGBT switch aging data as an example, 418 groups of data are used for measurement, experimental results show that the compression ratio of 3%-0.5% can be achieved for IGBT switching data without affecting the reconstruction accuracy.

▶ FriB03-2 10:30–10:50

L_1-stochastic Stability and L_1-gain Control for Positive 2D Markov Jump Systems

Duan, Zhaoxia Hohai Univ.
Sun, Yue Hohai Univ.
Xiang, Zhengrong Guangxi Univ. of Sci. & Tech.

In this paper, the L_1-stochastic stability and L_1-gain analysis of positive 2D Markov jump systems are studied based on Roesser model. Firstly, the mathematical model of 2D Markov jump systems is established, and the sufficient and necessary conditions (NSCs) of L_1-stability and sufficient conditions of L_1-gain calculation are given. Furthermore, a state feedback controller is designed to ensure that the system is a positive system with L_1 stochastic stability and a predetermined L_1-gain performance level. Finally, a numerical example is given to verify the effectiveness of the theoretical results.

▶ FriB03-3 10:50–11:10

Synchronous Control of Multi-motor Systems Using An Improved Relative Coupling Control Structure

Zheng, Yong North China Univ. of Tech.
Qu, Hao North China Univ. of Tech.
Zhao, Yijing North China Univ. of Tech.
Pang, Zhonghua North China Univ. of Tech.

In this paper, an improved relative coupled control structure (IRCCS) is proposed to suppress the overshoot and decrease the synchronization error of multi-motor synchronous control systems (MMSCSs). Different from the relative coupled control structure (RCCS), the IRCCS simplifies the speed compensator and combines with the idea of differential tracking controller, as well as introduces an improved differential negative feedback signal to speed loop controller which makes the speed controller desaturate in advance thus effectively suppressing the overshoot of the system. In addition, since the electromagnetic time constant is much smaller than the mechanical time constant, the synchronous error of MMSCSs can be decreased by introducing a compensation with the same synchronous compensation information as the speed loop controller to current loop controller. Finally, simulation analysis of the IRCCS is carried out on three-motor control system, and simulation results show that the IRCCS has better synchronization performance than the RCCS.

▶ FriB03-4 11:10–11:30

Stability Analysis of Continuous-time Switched Systems Based on Jordan Decomposition under Loop-dependent Dwell Time Approach

Yue, Zhang Shanghai Univ.
Song, Yang Shanghai Univ.
Zhao, Wanqing Univ. of East Anglia

In this paper, the concept of loop-dependent dwell time is proposed. The asymptotic stability and global uniform exponential stability of switched linear systems under the loop-dependent dwell time constraints are studied, which is completed by eigenvalue decomposition method of subsystem and matrix inequality method, respectively. This paper promotes and deepens the existing theoretical results based on Jordan decomposition, and obtains the less conservative sufficient conditions.

▶ FriB03-5 11:30–11:50

Optimal Tracking Control of DC Motors with Partially Unknown Dynamics

Liang, Xianglong Nanjing Univ. of Sci. & Tech.
Yao, Jianyong Nanjing Univ. of Sci. & Tech.

In this article, the nearly optimal tracking control scheme is established for dc motors with partially uncertain dynamics, including unknown drift dynamic and known control direction. The proposed optimal tracking control approach adopts dynamic inversion concept to acquire the feedforward compensation and then adopts reinforcement learning techniques to acquire the optimal feedback. The former derived by feedforward neural network is leveraged to estimate the unknown drift dynamic, and the latter is generated by direct heuristic dynamic programming (d-HDP) to solve a Hamilton-Jacobi-Bellman (HJB) equation. Eventually, theoretical analysis demonstrates that the closed-loop system signals are all bounded and the developed control scheme can achieve the optimal control input with a small bounded error. Simulation examples are implemented to validate the feasibility of the designed method.

▶ FriB03-6 11:50–12:10
Adaptive Model-Free Controller with Supervised Switching Technology of Upper Limb Exoskeleton

Xu, Jiazhen Nanjing Univ. of Sci. & Tech.
Tian, Yang Nanjing Univ. of Sci. & Tech.
Wang, Haoping Nanjing Univ. of Sci. & Tech.
Ma, Xingyu Nanjing Univ. of Sci. & Tech.
Guo, Yida Nanjing Univ. of Sci. & Tech.

A spherical scissor mechanism and an adaptive model-free controller with supervised switching method (SST-AMFC) were developed based on the previously proposed 7-DOF upper extremity exoskeleton iReHave to assist patients with impaired upper extremity motor function in completing the training required for rehabilitation. As a result, the iReHave II exoskeleton shoulder, which is based on SolidWorks, is proposed to increase the upper limb exoskeleton's performance. SST-AMFC (TDE-iPID) integrates TDE hyperlocal IPID model, time delay estimation technique, and PID controller performance on the original premise, using a line adaptive estimate methodology and intelligent PID control based on time delay estimation. Finally, the co-simulation results are combined with a comparison of the TDE-iPID controller to show how well the proposed SST-AMFC performs on the iReHave II 7-DOF upper limb exoskeleton robot.

FriB04 10:10–12:10 Room 5
Regular Session: Neural Networks, Fuzzy Systems Control in Data Driven Manner (I)

Chair: Feng, Jian Northeasten Univ.
Co-Chair: Liu, Shan Zhejiang Univ.

▶ FriB04-1 10:10–10:30
A Self-Training Multi-Task Attention Method for NILM

Li, Keqin Northeastern Univ.
Feng, Jian Northeasten Univ.
Xing, Yitong Northeastern Univ.
Wang, Bowen Northeastern Univ.

The key task of non-invasive load monitoring (NILM) is to know the power consumption of all household appliances, from which the power consumption of individual household appliance can be disaggregated. The power consumption and on/off state of household appliances are expected to be obtained, the multi-task learning model is used. One task is used to train the power comsumption of household appliances, the other task is used to train the on/off state of household appliances, and then these two results are combined as the final result. In this paper, a self-training multi-task learning model is proposed. In the model, a parallel structure is used to deal with two different tasks, and the outputs of two branches are directly combined as the final output. The model only needs one loss function and is only trained once. In addition, we also introduce attention mechanism into the proposed model. Finally, two public data sets are simulated to verify the effectiveness and superiority of the proposed method.

▶ FriB04-2 10:30–10:50
Identification Algorithm of Hammerstein Nonlinear System Using Neural Fuzzy Network and State Space Model

Yang, Hao Jiangsu Univ. of Tech.
Li, Feng Jiangsu Univ. of Tech.
Cao, Qingfeng Yangzhou Univ.

This paper discusses a two-stage parameter identification of Hammerstein nonlinear system by using neural fuzzy network and state space model. The developed Hammerstein systems are characterized by static nonlinear subsystems according to neural fuzzy network followed by a dynamic linear block modeled using state space model, and input test signals which is composed of binary signals and random signals are applied to parameter separation identification of the Hammerstein system, that is, estimate separately the underlying nonlinear block parameter and dynamic linear block parameter. To begin with, the parameters of linear block are estimated by way of recursive least square algorithm based on the input-output data of binary signals measurement. Moreover, Taylor series expansion theory and clustering algorithm are used to identify static nonlinear block parameters using random signals. Experiments show that the algorithm can identify the Hammerstein nonlinear system effectively and acquire excellent identification accuracy.

▶ FriB04-3 10:50–11:10
An Automatic Detection Approach for Wearing Safety Helmets on Construction Site Based on YOLOv5

Ge, Pengqiang Soochow Univ.
Chen, Yiyang Soochow Univ.

The environment of construction site is generally complex and uncertain, and there may be different kinds of unexpected potential risks. Therefore, it is necessary for construction workers to wear safety helmets on construction site, which saves their lives on sudden accidents. The traditional way to handle helmet wearing issue is through manual inspection and video surveillance, which has poor efficiency and lacks immediate warning. To solve this issue, the authors propose a helmet wearing detection approach based on YOLOv5 and annotate a dataset with 3,965 images. Then, the authors divide labelled dataset into training set (3,108 images) and validation set (857 images) to train the neural network with the pre-training weight YOLOv5s.pt. Lastly, the authors use the trained neural network to predict real scene images collected from the construction site. Experimental results indicate that safety helmet wearing detection using the trained YOLOv5 network performs well in term of high precision rate, high recall rate, low training classification loss, and low training objectness loss. In addition, it is capable of detecting safety helmets precisely as well as making a fair distinction between different categories.

▶ FriB04-4 11:10–11:30
Object Pose Estimation Based on Improved YOLOX Algorithm

Zhou, Yanhong Zhejiang Univ.
Liu, Shan Zhejiang Univ.

This paper proposes a deep learning method for object recognition and pose estimation only through a single RGB image. We extend the YOLOX algorithm, which has excellent performance in the field of 2D object detection, making it suitable for 6DoF pose estimation scenarios in a natural way. The model is designed to predict the position of key points in the image, which are used to establish the correspondence between the object model and the scene image. After that, the object pose can be obtained by PnP algorithm. In order to obtain labeled data for model training effectively, this paper designs a data augmentation method combining offline expansion and online augmentation, which can improve the generalization ability of the model. The results of experiments on the LINEMOD dataset demonstrate the effectiveness of our method, which is significantly competitive with other methods using similar implementation ideas.

▶ FriB04-5 11:30–11:50
Enhancing EEG Motor Imagery Decoding Performance via Deep Temporal-domain Information Extraction

Yang, Qihong Chongqing Univ. of Posts & Telecommunications
Yang, Mingzhao Chongqing Univ. of Posts & Telecommunications
Liu, Ke Chongqing Unversity of Posts & Telecommunications
Deng, Xin Chongqing Univ. of Posts & Telecommunications

Electroencephalography (EEG) based motor imagery Brain-Computer Interface (MI-BCI) has been widely applied in constructing a pathway between human brains and external machines. However, decoding of MI-EEG signals is challenging as EEG is severely affected by non-stationarity and high variability in signal patterns. In this work, to fully extract the spatial and temporal information of EEG for MI decoding, we designed an end-to-end compact deep convolutional neural network model, combining EEGNet and a temporal convolutional network. The proposed model requires few data pre-processing and a small number of trainable parameters, achieving significant performance improvement on MI-EEG decoding tasks. Experimental results under the subject-dependent manner show that our method achieves 56.73%, 73.9%, and 75.4% classification accuracy on the 2020 BCIC, Same Limb, and OpenBMI datasets, respectively, which outperforms the state-of-the-art (STOA) convolutional neural network (CNN). Under the subject-independent with the 2020 BCIC dataset, the proposed approach achieves an accuracy improvement of 2.8% compared to the STOA CNN. The code of the proposed method is available at https://github.com/ingod/DDCLS-MI-EEG-BCI-.

▶ FriB04-6 11:50–12:10
PMSM Field Orientation Control Based on Online Neuron PID

Zhao, Duo Southwest Jiaotong Univ.
Cai, Jianchang Southwest Jiaotong Univ.

Permanent Magnet Synchronous Motor (PMSM) is a nonlinear and strong coupling complex system. For the traditional PMSM control system using PID controller, there are problems such as difficult parameters tuning, long time consumption, parameters mismatch, etc. This paper proposes an online Neuron PID controller for PMSM Field Orientation Control system. Neuron PID uses the function approximation and self-learning abilities of neural network to tune control parameters online.

The simulation and experimental results show the PMSM Field Orientation Control system based on Neuron PID has the advantages of good robustness, fast response speed and strong anti-disturbance ability.

FriB05 10:10–12:10 Room 6

Regular Session: Data-driven Fault Diagnosis and Health Maintenance (II)

Chair: Zheng, Ying Huazhong Univ. of Sci. & Tech.
Co-Chair: Yang, Xu Univ. of Sci. & Tech. Beijing

▶ FriB05-1 10:10–10:30

Industrial Imbalanced Fault Diagnosis Method Based on Borderline SMOTE Integrated with NPE and CatBoost

Zhu, Qunxiong Beijing Univ. of Chemical Tech.
Wang, Xinwei Beijing Univ. of Chemical Tech.
Zhang, Ning Beijing Univ. of Chemical Tech.
Xu, Yuan BEIJING Univ. OF CHEMICAL Tech.
He, Yan-Lin Beijing Univ. of Chemical Tech.

The data collected in modern process industry have imbalanced, high-dimensional and non-linear features, which bring great challenges to chemical process fault diagnosis. Facing these features of data, we present a new fault diagnosis method based on Borderline Synthetic Minority Over-Sampling Technique (BorSMOTE) integrated with Neighborhood Preserving Embedding (NPE) and CatBoost named BSNC. In the proposed BSNC, BorSMOTE is an improved oversampling method based on SMOTE, which improves the class distribution of samples by using only minority class sample on the boundary to synthesize some new samples; NPE is used for dimensionality reduction (DR) to extract critical features associated with faults; finally, CatBoost is used as a classifier to identify the fault types. In order to verify the feasibility of the proposed BSNC methodology, the Tennessee Eastman process (TE) with different types of fault data is chosen for simulation experiment validation. The simulation results show that the BSNC methodology in this paper has considerable performance compared with the data in the imbalanced state and the related DR methodologies.

▶ FriB05-2 10:30–10:50

Feature Extraction of Sequence Data Based on LSTM and Its Application to Fault Diagnosis of Industrial Process

Yang, Xiaojun Tsinghua Univ.
Wan, Chuan Tsinghua Univ.
Zhang, Tongshuai Tsinghua Univ.
Xiong, Zhihua Tsinghua Univ.

Data with sequential relationships such as text, speech, and sensor data, belong to sequence data. Many deep learning models are proposed to extract features and learn internal information. We investigate the similarities and differences of the modeling methods of sequence data in various fields, and uses deep learning neural network to build a model for the fault diagnosis of sequence data in process industry. Long-short-term memory (LSTM) network and feature extraction of contrastive predictive coding (CPC) are used in this paper for modeling and experiments. CPC can learn a representation of data, and LSTM can learn the information contained in sequence data. The model combining CPC and LSTM can distinguish normal data from various fault data and realize fault diagnosis. Experiments on the Tennessee-Eastman process show that the LSTM network model combining with proper feature extraction methods can improve the performance of fault diagnosis.

▶ FriB05-3 10:50–11:10

A Fault Detection and Isolation Method Based on Supervised Nonnegative Matrix Factorizations

Zhai, Lirong Liaoning Univ.
Sun, Siqi Liaoning Univ.
Gao, Zhe Liaoning Univ.
Weng, Yongpeng Dalian Maritime Univ.

Standard nonnegative matrix factorization (NMF) is a powerful algorithm for data analysis and processing. In this paper, we improve the standard NMF and propose a supervised NMF algorithm that uses labeled samples for model training. The new NMF can identify the label of samples and achieve clustering. Using the clustering property of the supervised NMF algorithm, fault detection and isolation (FDI) is developed when both fault-free samples and all types of faulty samples are available for model training. Finally, the effectiveness of the proposed FDI approach is verified by an experiment on FDI of the penicillin fermentation process (PFP).

▶ FriB05-4 11:10–11:30

A Prototypical Networks-based Multi-task Model for Few-shot Fault Diagnosis

Huo, Zhihao Huazhong Univ. of Sci. & Tech.
Yang, Xiaoyu Huazhong Univ. of Sci. & Tech.
Yang, Tao Huazhong Univ. of Sci. & Tech.
Fan, Huijin Huazhong Univ. of Sci. & Tech.
Su, Housheng Huazhong Univ. of Sci. & Tech.
Zheng, Ying Huazhong Univ. of Sci. & Tech.

Due to the powerful classification performance, Prototypical Networks is widely used in few-shot fault diagnosis. However, insufficient feature extraction ability and negligence of inter-class distance in the Prototypical Networks may lead to the decrease of diagnosis accuracy. To solve the above problems, a Prototypical Networks-based multi-task model (PNBMTM) is proposed in this paper. Firstly, a convolutional autoencoder is built based on the feature extraction network of the Prototypical Networks, in which the optimization of the reconstruction loss is taken as a new task to obtain more efficient features. Secondly, a channel attention module (CAM) is designed to be applied to each layer of the encoder, which focuses on important features and suppresses useless features. Thirdly, relative distance loss is introduced while considering the effect of intra-class distance and inter-class distance to make inter-class distance larger and intra-class distance smaller, which helps to improve the quality of the features. And the optimization of relative distance loss is consequently taken as a new task to constitute a multi-task fault diagnosis model. Finally, a mechanical fault simulation experiment platform is built to verify the validity of the proposed model. The experimental results show that the proposed model has superior performance compared with other models.

▶ FriB05-5 11:30–11:50

Fault-Tolerant Control Based on State Observer and Optimal Allocation for Four-Wheel Independent Drive Electric Vehicle

Li, Fengyang Uestc
Chen, Yong Univ. of Electronic Sci. & Tech. of China
Tang, Hui Uestc

In this paper, the tracking control problem and the lateral stability problem of four-wheel independent drive electric vehicle(4WID-EV) system under actuator failure condition are studied. Firstly, the 7 degrees of freedom (DOF) vehicle model and linear 2 DOF ideal vehicle model are constructed in this paper. Secondly, a nonlinear state observer is designed to track the ideal system states. Then, a two-layer controller is designed to maintain the longitudinal motion performance and lateral stability of the vehicle by adjusting the input voltage of the four in-wheel motors to control both the longitudinal drive moment and the yaw moment, where the sliding mode controller (SMC) and quadratic programming are used in the upper and lower controllers, respectively. Finally, the effectiveness of the proposed method is verified in three different maneuvers.

▶ FriB05-6 11:50–12:10

Automated Pap Smear Cervical Cancer Detection Based on Multiscale Convolutional Neural Network

Xia, Mingyang Tianjin Univ.
Zhang, Guoshan Tianjin Univ.
Guan, Bin Tianjin Univ.

Cervical cancer is one deadly common gynecological malignant tumor, early accurate screening detection can save lives. However, the large-scale manual screening is limited by the few experienced cytologists, which is difficult to change under the existing conditions. In this paper, we propose an automatic detection framework based on deep learning to improve the detection accuracy and efficiency of cervical cancer cells. Different from the traditional convolutional neural network with a top-down structure, we design an isomorphic dual-branch residual-like structure as a multi-scale network. The multi-scale network can increase the range of the receptive field with each network layer at a fine-grained level to accurately learn the representation information of pathological images. In addition, we also perform ablation studies on different widths, residual block types, and patch extraction methods in the backbone network. The experimental results show that our framework has achieved an AP of 89.7% in cervical cancer cell detection, which is superior to other existing detection frameworks.

FriB06 10:10–12:10 Room 7

Regular Session: Neural Networks, Fuzzy Systems Control in Data Driven Manner (II)

Chair: Deng, Xin Chongqing Univ. of Posts & Telecommunications
Co-Chair: Jin, Huaiping Kunming Univ. of Sci. & Tech.

▶ FriB06-1 10:10–10:30

Diabetic Retinopathy Diagnosis Based on Transfer Learning and Improved Residual Network

Chai, Rongmin — Beijing Univ. of Chemical Tech.
Chen, Di — Shandong First Medical Univ.
Ma, Xin — Beijing Univ. of Chemical Tech.
Liu, Shengyan — The Second Affiliated Hospital of Shandong First Medical Univ.
Wang, Yi — Shandong First Medical Univ.
Wang, Youqing — Beijing Univ. of Chemical Tech.

Diabetic retinopathy (DR) is a common complication of diabetes. Effective DR detection can help diabetic patients seek medical treatment in a timely manner and reduce the risk of blindness. In this study, the attention mechanism SE-block was integrated into the residual network to improve the ability of lesion detection, and combined with the transfer learning method to solve the problem of small sample size. Applies the proposed method to its own proprietary dataset and the IDRiD dataset for referable DR diagnosis. Experimental results show that the method achieves superior classification performance.

▶ FriB06-2 10:30–10:50

Emotion Recognition Method Based on EEG in Few Channels

Deng, Xin — Chongqing Univ. of Posts & Telecommunications
Lv, Xiangwei — Chongqing Univ. of Posts & Telecommunications
Yang, Pengfei — Chongqing Univ. of Posts & Telecommunications
Liu, Ke — Chongqing Unversity of Posts & Telecommunications
Sun, Kaiwei — Chongqing Univ. of Posts & Telecommunications

EEG acquired by wearable devices can effectively monitor human emotion. Some traditional methods based onsome artificial designed features and deep learning technology have achieved good results in emotion recognition based on theEEG signals. However, in the actual experimental process, there are still some problems, such as the high number of channels,the feature redundancy and so on. These challenges hinder the application of the emotion recognition in portable wearabledevices. This paper proposes a 4-channel method to achieve the classification accuracy in more channels (62 channels in SEEDdataset and 14 channels in our dataset). In this paper, a parallel signal processing method, which is based on the intrinsictime scale decomposition (ITD), discrete wavelet transform (DWT), variational mode decomposition (VMD) and phase spacereconstruction(PSR), is proposed to obtain more modes of signals. The differential entropy for each mode is extracted as thefeature, and the linear dynamic system is used to smooth the feature. Based on the artificial features, this paper designs a simpleCNN model with fewer parameters to complete the classification task. It also applies this method to SEED dataset and our owndataset, and carries out three types of experiments. Experimental results show that the average accuracy of the method in 4channels can reach the performance of more channels. Due to the versatility of this method, it is expected to be more widelyused in wearable devices with weak computing power under 4 channels.

▶ FriB06-3 10:50–11:10

Integral Sliding Mode Control for Partially Unknown T-S Fuzzy Systems Based on Reinforcement Learning Method

Sun, Xingjian — Nantong Univ.
Shi, Min — Nantong Univ.
Chen, Nan — Nantong Univ.
Gu, Juping — Nantong Univ.

This article focus on the integral sliding mode control for a class of partially unknown T-S fuzzy systems on the basis of reinforcement learning technique. In the equivalent control, the control term is described as a form of feedback control based on the percompensation technique, such that the optimal control performance can be satisfied. Then the control gain is design by solving the algebraic Riccati equation according to the integral reinforcement learning (RL) method, and the requirements of exact information of system matrices is relaxed during the solving process. Base on the Lyapunov stability theory, the convergence and stability of the designed sliding mode control optimization scheme are analyzed. Finally, a numerical example is given to verified the effectiveness of the proposed theorems.

▶ FriB06-4 11:10–11:30

Distributed Cooperative Control of High-Speed Trains with Input Saturation and Unmodeled Dynamics

Zhu, Lei — Southwest Jiaotong Univ.
Huang, Deqing — Southwest Jiaotong Univ.
Li, Xuefang — National Univ. of Singapore

In this work, a distributed cooperative control strategy is proposed for multiple high-speed trains (MHSTs) subject to input saturation and unmodeled dynamics. To facilitate the distributed controller design, the dynamics of trains are firstly modeled as a muti-agent system (MAS) with a state-dependent directed graph. Then, the distributed control laws that are equipped with a command filter and a robust adaptive neural network are developed to achieve the consensus task among the MHSTs with predefined displacement and speed trajectories. It should be highlighted that, to reduce the complexity of the control algorithms and computational burden, we propose adaptive estimation laws to estimate the upper bound of the norm of the neural network weight vectors, instead of the weights themselves. Further, an auxiliary dynamical system (ADS) is introduced to compensate the influence of the input saturation. The convergence of the proposed controllers are analyzed rigorously by applying Lyapunov theorem, and the effectiveness of the proposed control approach is demonstrated by numerical simulations.

▶ FriB06-5 11:30–11:50

Combining Virtual Sample Generation Based Data Enhancement and Multi-objective Optimization Based Selective Ensemble for Soft Sensor Modeling

Huang, Shuqi — Kunming Univ. of Sci. & Tech.
Jin, Huaiping — Kunming Univ. of Sci. & Tech.
Yang, Biao — Kunming Univ. of Sciecnce & T
Liu, Haipeng — Kunming Univ. of Sci. & Tech.

Soft sensor modeling technology realizes the real-time estimation of difficult-to-measure variables by constructing the mathematical model between secondary variables and primary variable. Nevertheless, sufficient and high-quality training samples are difficult to obtain owing to the high cost of data acquisition and low sampling rate. To solve this, a soft sensor modeling method，combining virtual sample generation based data enhancement and multi-objective optimization based selective ensemble (DESE), is proposed. First, a supervised variational autoencoder (SVAE) is constructed by introducing quality variable. Second, a generative model is built through the combination of SVAE and Wasserstein GAN with gradient penalty (WGAN-gp). Third, SV-WGANgp is trained on each sample subset, which is obtained by resampling, and a fixed number of virtual samples are generated. A set of base models is established for the expanded original samples subsequently. Finally, the multi-objective optimization method is utilized to prune these models, which satisfy both accuracy and diversity requirements. After integrating the selected base models, the final prediction results are obtained. Experimental results verify that, compared with the other three popular generation models, DESE significantly improves the prediction performance of soft sensor model by supplementing the original samples.

▶ FriB06-6 11:50–12:10

Soft Sensing Method Based on Online Dynamic Clustering and Self-labeling

Wang, Yuechen — Kunming Univ. of Sci. & Tech.
Jin, Huaiping — Kunming Univ. of Sci. & Tech.
Yang, Biao — Kunming Univ. of Sciecnce & T
Liu, Haipeng — Kunming Univ. of Sci. & Tech.

Traditional soft sensing methods encounter low prediction accuracy owing to complex process characteristics, such as time-varying and nonlinear behaviors, as well as the scarcity of labeled data. A soft sensing method based on online dynamic clustering and self-labeling (ODCSL) is proposed for data stream mining of industrial processes. This method identifies the process state of the data stream through online clustering analysis, and then adaptively establishes a local Gaussian process regression (GPR) for online prediction. During each prediction run, self-labeling is performed on the recently unlabeled data to provide good pseudo-labeled data, which enhances the prediction of local GPR models. Moreover, when a new sample is available, the clustering results and the GPR models are updated. The effectiveness of the proposed ODCSL method is verified using an industrial fermentation process.

Poster Session FriB07
Aug. 5, 10:10–12:10
Emei Ballroom

Chair: Ai, Wei — South China Univ. of Tech.
Co-Chair: Hu, Chaofang — Tianjin Univ.

▷ FriB07-01

Event-Triggered Adaptive NN Control for A Class of Unknown Stochastic Nonlinear Systems under DoS Attacks

Han, Luheng Xidian Univ.
Li, Jing Xidian Univ.

In this paper, a resilient control problem is investigated for a class of stochastic nonlinear systems under denial-of-service attacks. First, the unknown nonlinear noise strength is approximated by a neural network. Then, an event-triggering mechanism is designed to save resources and a sufficient condition is given to guarantee the system state semi-global mean-square uniformly ultimately bounded. Finally, the effectiveness of the proposed control strategy is demonstrated by a numerical example.

▷ FriB07-02

Extraction Method of Characteristic Indicators for Travel on the Key Corridor

Zhang, Shuai North China Univ. of Tech.
Tan, Jiyuan North China Univ. of Tech. Beijing
Feng, Yan North China Univ. of Tech.
Luo, Wenxiu North China Univ. of Tech.

Based on cell phone signaling data, data analysis methods such as buffer analysis, Tyson polygon, and distance threshold determination were used to establish a matching relationship between base stations and corridors from the perspective of travelers. The method of regression analysis was used to mine the characteristics of travelers' demand and travel behavior. The paper analyzed and established characteristics indicators for travelers. Taking the Beijing–Lhasa Expressway as an example, the method of regression analysis was used to mine characteristics in terms of the basic attributes of the user including the number of trip and the number of trip days. At the same time, this method of regression analysis was used to explore the time characteristics of travelers' patterns including departure time and travel time. And this method of regression analysis was used to explore the spatial characteristics of travelers' patterns including trip occurrence and attraction. The research could provide an important theoretical basis for traffic managers to make decisions.

▷ FriB07-03

Obstacle Avoidance Path Planning and Motion Control for A Multi-joint Soft Manipulator

Cao, Zhiyan Shanghai Univ.
Huang, Tianyu Shanghai Univ.
Bao, Zhiwen Southeast Univ.
Xie, Yangmin Shanghai Univ.
Shi, Hang Shanghai Univ.

One of the most challenging tasks for soft manipulators is to avoid obstacles in a cluttered workspace. This paper aims to solve the problem by providing both an obstacle avoidance path planning method and a path following control strategy. To form a general framework for path planning, we proposed a collision map generation method in configuration space, which allows the usage of a general graph search or random sampling method to find a feasible obstacle-free path. In addition, to deal with the high nonlinear dynamics of soft manipulators, we design a gain-scheduling controller in the loop of pressure control, which adaptively tunes the controller gain along with the current operating pressures, and as a result, guarantees a unified performance for different deformation levels. The methods are testified on a three degree of freedom (DOF) soft manipulator and proven to be effective for obstacle avoidance tasks in cluttered environments.

▷ FriB07-04

A Review of Research on Intelligent Control Algorithm Applied to Power Line Inspection Robot

Chen, Beining Hohai Univ.
Feng, Yanbo Hohai Univ.
Cao, Yuhan Hohai Univ.

This paper reviews the intelligent control algorithms applied to power line inspection (PLI) robots. This paper introduces the application of intelligent control algorithm in global environment detection, local obstacle recognition and self-balancing control of PLI robot. And this paper point out the problems existing in the current research and the future development direction.

▷ FriB07-05

Model Free Adaptive Traffic Signal Control for Four-phase Intersections

Yin, Hao North China Univ. of Tech.
Ren, Ye Beijing Jiaotong Univ.
Wang, Li North China Univ. of Tech.
Ji, Honghai North China Univ. of Tech.
Liu, Shida Beijing Jiaotong Univ.

In the paper, an engineering-oriented model free adaptive control scheme is proposed for four-phase intersections. To achieve the queuing length equilibrium, the queuing length differences of each phase are taken as objective functions. The proposed method is applied to a single four-phase intersection and simulated in both medium and high traffic demand. Through the simulation, the proposed algorithm can make the queuing lengths of each phase at the intersection more balanced, and the average delay time of the vehicles is less. Therefore, the proposed control method is superior in the case of large randomness of vehicle arrival at each phase and large difference of traffic demand at each phase.

▷ FriB07-06

Transformer Fault Diagnosis Based on PSO-RF Characterised by Modified CNN-encoder

Song, Maojia Southwest Jiaotong Univ.
Luo, Yicheng Southwest Jiaotong Univ.
Liu, Shixiao Southwest Jiaotong Univ.
Fan, Jingwei Southwest Jiaotong Univ.
Li, Mingyue Southwest Jiaotong Univ.
Liu, Dong Southwest Jiaotong Univ.

Oil immersed transformer is one of the most important equipment in power grid. Improving performance of such transformer fault diagnosis to ensure more stable power system is of great significance to safe operation. By analysing dissolved gases in oil, a fault diagnosis model based on Particle Swarm optimised Random Forest (PSO-RF), with features integrated by improved CNN-encoder, is proposed. Firstly, the raw volume fraction of dissolved gases is processed by 1-dim Convolutional layers to form a new combined features by machine. Secondly, current popular coded methods are integrated to produce final effective features that are sorted to obtain least 90% of the information. Finally, feature vectors are applied to fault diagnosis model based on PSO-RF. The experimental results show that accuracy of diagnosis model is achieved by 93.33% in test set. Compared with traditional models, this method has better feature searching with sufficient accuracy in small sample size, providing better responsiveness in practical applications of transformer diagnosis.

▷ FriB07-07

Defect Detection of Track Fasteners Based on Pruned YOLO V5 Model

Wang, Xinyu Southwest Jiaotong Univ.
Zhang, Jiali Southwest Jiao Tong Univ.
Wang, Yuwei Southwest Jiaotong Univ.
Liu, Dong Southwest Jiaotong Univ.
Li, Mingyue Southwest Jiaotong Univ.

With the increase of people's demand for rail transportation, the safety maintenance of rail lines has become particularly critical. At present, the widely used manual detection method has a series of shortcomings, such as low accuracy, long cycle, and low efficiency. In order to improve this situation, this paper proposed a defect detection method for track fasteners based on YOLO V5 and combined with the model pruning technology of FPGM algorithm to provide a certain margin for the expansion of model width and depth, so as to achieve the optimal model after the tradeoff between the improvement of recognition accuracy and the inference speed. Based on YOLO V5s, the experiment proved that the YOLO V5m model could improve the average accuracy (mAP) from 91.23% to 93.42%, and the detection speed from 58.1fps to 78.3fps, which completed the double improvement of accuracy and speed, and could carry out the fastener defect identification task more efficiently. At the same time, it provides a feasible improvement method for further deployment of higher order model network in the cloud.

▷ FriB07-08

Remaining Useful Life Prediction of Rolling Bearings Using Correlation Coefficient Based Long Short-Term Memory Neural Network

Wang, Chenyang China Nuclear Power Tech. Research Inst. Co. Ltd
Yin, Chaolin China Nuclear Power Tech. Research Inst. Co. Ltd
Bai, Shan China Nuclear Power Tech. Research Inst. Co. Ltd
Han, Yongming Beijing Univ. of Chemical Tech.

Rolling bearings play a crucial component for machinery equipment, which affects the operation efficiency and safety of the machinery equipment. The remaining useful life (RUL) prediction of rolling bearings is helpful for intelligent maintenance of the mechanical equipment. Therefore, an improved correlation coefficient based long short-term memory (LSTM) neural network model is presented in this paper to realize the RUL prediction of rolling bearings. First, the time domain, frequency do-

main and time-frequency domain features are extracted from the rolling bearing vibration data. Meanwhile, the noise reduction and normalization of the extracted features are conducted. Then, some important features that represent the bearing degradation trend are selected as the training data set through the correlation coefficient method to construct the RUL prediction model of online rolling bearings. Finally, the superiority of the presented RUL prediction model is validated baesd on the XJTU-SY rolling bearing data. Results on the experimental data indicate that the presented RUL prediction model has high generalization ability and high accuracy.

▷ FriB07-09

A Fault Diagnosis Approach Integrated LPP with AROMF for Process Industry

Xu, Yuan	Beijing Univ. of Chemical Tech.
Wang, Zixu	BUCT
Ke, Wei	Macao Polytechnic Inst.
He, Yan-Lin	Beijing Univ. of Chemical Tech.
Zhu, Qunxiong	Beijing Univ. of Chemical Tech.
Zhang, Yang	Beijing Univ. of Chemical Tech.

As the data collected in the industrial process presents high-dimensional and nonlinear characteristics, it brings great challenges to the realization of timely and effective fault diagnosis. In this article, a fault diagnosis method is proposed integrated local preserving projections(LPP) with adaptive rank-order morphological filter(AROMF).First, in order to deal with the problem of high-dimensional and non-linearity of data, LPP algorithm is used to extract the required template trend and test trend. Second, AROMF performs morphological transformation on the test trend under the supervision of the template trend to obtain the output trend signal. Third, the iterative total error of the output trend and the corresponding template trend is calculated to classify the fault. Finally, the proposed method is verified by simulation on the Three-phase flow facility(TFF) dataset. The simulation results prove that this method can improve the accuracy of fault diagnosis.

▷ FriB07-10

Covid-19 Epidemic Trend Prediction Based on CNN-StackBiLSTM

Li, Zhenyu	Huazhong Univ. of Tech.
Wang, Yang	Huazhong Univ. of Sci. & Tech.
Wang, Yanwei	Wuhan Inst. of Tech.
Zheng, Ying	Huazhong Univ. of Sci. & Tech.
Su, Housheng	Huazhong Univ. of Sci. & Tech.

In late 2019, the novel coronavirus (COVID-19) became a major health hazard around the world. Recently, the COVID-19 has spread widely in most countries and regions and the number of infected people continues to grow rapidly. Therefore, it is essential to research the development trend of the epidemic. The prediction of the number of infections and deaths is critical and helpful for developing health and epidemic prevention strategies and even curbing the epidemic. In this paper, a one-dimensional convolutional neural network combined with the stacked long-short-term-memory network model (CNN-StackBiLSTM) is proposed for the time-series prediction of cumulative cases and daily new cases. The local feature is extracted by CNN. The stacked BiLSTM captures the deeper characteristics of the time-series data. By combining the two networks, the proposed method simultaneously considers the information of temporal and spatial domains and can achieve accurate prediction results. Examples in Taiwan and Italy demonstrate the effectiveness of the proposed method. The proposed method is compared with LSTM, BiLSTM, and GRU. The mean absolute error, mean square error, R2 score, and root mean square error are calculated to quantificationally measure the different models. The results indicate the proposed method performs well in the prediction of both new daily confirmed cases and cumulative confirmed cases.

▷ FriB07-11

A Novel Fault Diagnosis Method Based on Multi-class Probabilistic SVDD

Zhang, Chuanfang	Univ. of Sci. & Tech. Beijing
Peng, Kaixiang	Univ. of Sci. & Tech. Beijing
Dong, Jie	Univ. of Sci. & Tech. Beijing, China
Ma, Liang	Univ. of Sci. & Tech. Beijing
Zhang, Xueyi	Univ. of Sci. & Tech. Beijing

In industrial processes, fault diagnosis is of great practical significance for guiding the production adjustment for operators. From the perspective of classification, fault diagnosis is considered as a multi-class classification problem. As a well-known one-class classifier, support vector data description (SVDD) can only give the target data set a spherically shaped description, which is a binary output. However, the collected data in real industrial processes often contains more than one class of faults and each fault need to be identified. Traditional methods usually build a SVDD model for each class, which ignores the correlation among different classes. Compared with binary output, taking probability as the output result can provide more information and obtain more accurate data description. Thus, a fault diagnosis method based on multi-class probabilistic SVDD (MP-SVDD) is proposed in this work. MPSVDD considers the interactions among different classes in a unified way, and the distance from the sample to centre of sphere is converted into a probability expression. Simulation results on a hot tandem rolling mill process illustrate the effectiveness of the proposed method comparing to the traditional multi-class SVDD.

▷ FriB07-12

Data-driven Adaptive Optimization Recursive Identification for A Discrete-time Nonlinear System

Liu, Shida	Beijing Jiaotong Univ.
Wang, Yulin	College of Electronics & Control Engineering, North China Univ. of Tech., Beijing
Fan, Lingling	Beijing Information Sci. & Tech. Univ.
Wang, Li	North China Univ. of Tech.
Wei, Yuzhou	College of Electronics & Control Engineering, North China Univ. of Tech., Beijing
Ji, Honghai	North China Univ. of Tech.

Abstract: In this paper a novel data-driven adaptive optimization recursive identification (DD-AORI) is proposed which applies for discrete-time nonlinear systems. The dynamic linearization technique is used to equivalently transform discrete-time nonlinear systems into the form of data-driven model. An optimal and convergent estimation for quickly time-varying parameters including its parameter update rate and covariance update rate is obtained by optimization indexes and Lyapunov convergence. The method improves the tracking ability of time-varying parameters by increasing the use of historical data. The damping factor is used to improve the dynamic effect of the system. To improve the estimation effect, the utilization ratio of new data is increased by forgetting factor. Simulation results are presented to verify the effectiveness of the proposed method.

▷ FriB07-13

Face Landmark Calibration Based on 3D Reconstruction and Deep Learning

Hu, Boyang	North China Univ. of Tech.
Deng, Jinzhao	North China Univ. of Tech.
Li, Dan	North China Univ. of Tech.
Long, Zhou	North China Univ. of Tech.
Sun, Wenhao	North China Univ. of Tech.
Zhang, Xiaoping	North China Univ. of Tech.
Yan, Jiaqing	North China Univ. of Tech.

Face alignment is an important research field in machine vision, favors many application such as face recognition, expression recognition, pose estimation, and face synthesis. However, many algorithms are design for faces in small poses and good lighting, they does not perform decent in the wild. In this paper, we propose a face alignment algorithm to improve the accuracy of face landmark. This approach begins with a network to locate face landmark in general and employs a face normalization to reduce disturbing redundant information. Then we introduce a 3D facial reconstruction and getting exact camera matrix, Euler angle by 3D reconstruction, eliminating the effect of pose for face landmark. Experiments on the IBUG dataset show that our method achieves improvement over state-of-the-art methods.

▷ FriB07-14

Learning Optimization for Dispatch of Interregional Power Grid under Uncertain Environment

Tang, Hao	Hefei Univ. of Tech.
Zhang, Yan	Hefei Univ. of Tech.
Li, Xiaoqing	Hefei Univ. of Tech.
Lv, Kai	Hefei Univ. of Tech.

This study investigates the dispatch problem in interregional power grids with uncertain renewable energy source sand loads. A knowledge-transfer-based hierarchical learning optimization method is designed to search for the optimal dispatch strategy. First, the model of various sources, loads, and tie-lines are established according to each components characteristics in the system. The dispatch process of an inter-

regional power grid is correspondingly divided into tie-line dispatch in the upper layer and both generator units and flexible load dispatch in the lower layer. The dispatch optimization problems of both layers are formulated with a hierarchical Markov decision process model. Finally, a learning optimization method is adopted to obtain the dispatch strategy, in which a pre-learning technique is incorporated. A case study is performed to validate the effectiveness of the proposed method, and the simulation results show that the pre-learning technique improves the learning speed and reducesthe cost of relearning.

▷ FriB07-15

Open-loop NARX based Modeling of a Hybrid-electric Turboshaft Engine' s Startup Process

Li, Zhilin — Beijing Inst. of Tech.
Ma, Yue — Beijing Inst. of Tech.

The modeling of the startup process of a turboshaft engine has always been a difficult task, which is further aggravated on a turboshaft engine in a hybrid-electric system. With sufficient data from bench experiments, this article establishes a data-driven numerical model to simulate the startup process of a hybrid-electric turboshaft engine. Neural networks are organized hierarchically to estimate two key parameters of the engine system: engine speed and exhaust temperature. The proposed model is built, trained, and tested in sections, and then tested as a whole. According to the running tests, it can give accurate results using a rather simple framework, showing great potential as a reference model on real-time control units.

▷ FriB07-16

Data-based Modeling and Simulation of Denso Robotic Arm

Liu, Shoufu — Tianjin Univ.
Dong, Na — Tianjin Univ.
He, Kesen — Tianjin Univ.
Mai, Xiaoming — Tianjin Univ.

Robotic arms now play an important role in various fields and have more and more extensive applications. However, robotic arm systems are complex nonlinear systems with multiple inputs and outputs. Its parameters have great uncertainty, strong coupling, internal friction and external disturbance, which make it difficult to construct an accurate dynamic model. In this paper, a data-driven modeling method of the Denso robotic arm is proposed based on the BP neural network. The main research contents of the subject are as follows: The Denso robotic arm is taken as the research object, and the hardware platform of the robotic arm is designed and built. The data acquisition of the robotic arm is carried out by the hardware platform built in our lab, and the BP neural network is used to simulate the Denso robotic arm model. The simulation results show that the robotic arm model based on BP neural network proposed in this paper performs well in fitting effect.

▷ FriB07-17

Multi-Model Tube-MPC Fault-Tolerant Control for Flexible Hypersonic Vehicle

Mi, Hanpeng — Tianjin Univ.
Hu, Chaofang — Tianjin Univ.
Yang, Xiaohe — Tianjin Univ.
Hu, Yongtai — Flight Automatic Control Research Inst.

For the large flight envelope and high maneuverability of flexible hypersonic vehicle, a Tube-MPC fault tolerant control strategy based on multiple models is presented. First, the flight area is divided into subspaces. In each subspace, a control-oriented linearized submodel is constructed using the Jacobian linearization method, and fault and parameter uncertainties are included in the additional disturbance terms. Then, a fault-tolerant controller based on Tube-MPC is designed for the submodel to achieve the stability control of the aircraft in the local range. Finally, each submodel controller is weighted by an appropriate multi-model weighting strategy to obtain the final control law. This strategy ensures the stable flight of the flexible hypersonic vehicle in the failure state throughout the flight envelope. The simulation results show that the proposed control method is effective.

▷ FriB07-18

Global Path Planning Method by Fusion of A-star Algorithm and Sparrow Search Algorithm

Chen, Yangde — Huzhou Univ.
Wang, Peiliang — Huzhou Univ.
Lin, Zichen — Huzhou Univ.
Sun, Chenhao — Huzhou Univ.

A global path planning method (A-SSA) that integrates the A-star algorithm and Sparrow Search Algorithm (SSA) is proposed for the shortest path planning problem of Automated Guided Vehicles (AGV) in a static raster environment. The first stage of the method uses the sparrow algorithm to obtain several key grid points in the raster map, and then uses the A-star algorithm to connect these grid points; the second stage uses the ray method to remove the redundant nodes, and then uses the Bessel curve to generate a continuous, collision-free and smooth shortest path after obtaining the simplified vital nodes. The back-off mechanism is studied for the deadlock problem in path planning, simulation experiments are conducted for the three algorithms within a 30×30 raster map with obstacle coverage of 20%, 25%, 30%, 35%, and 40%, respectively, and the experimental results show that the path length planned by the A-SSA method is the shortest, which proves the effectiveness of the method and can provide a The experimental results show that the path length of the A-SSA method is the shortest, which demonstrates the effectiveness of the method and can provide some reference for the shortest path planning of AGV.

▷ FriB07-19

Partition Weighted Delay-timer for Industrial Alarm Monitoring

Xin, Kaiqiang — China Nuclear Power Operation Tech. Corporation, LTD
Ba, Jun — Research Inst. of Nuclear Power Operation

Alarm systems are to alert operators of abnormal operating conditions and equipment malfunctions, with the intent to avoid property damage and major safety incidents. Delay-timer is a widely used technique in alarm system design, which can effectively improve the accuracy of alarm systems. However, conventional delay-timer has not taken advantage of the information contained in a process variable, so that the delay-timer makes alarm system more insensitive to abnormal condition while improve the accuracy of alarm systems. In order to make use of the full information of a process variable, and improve the performance of industrial alarm systems, this paper proposes a partition weighted delay-timer alarming technique. Simulations and industrial results show that alarm performance can be improved via the proposed technique with a proper choice of partition

▷ FriB07-20

Automated Classification of Cervical Image Based on Deep Neural Network

Zhao, Mengying — Tianjin Univ. of Tech.
Zhang, Liyan — Tianjin Univ. of Tech.
Wang, Juan — Tianjin Univ. of Tech.
Xia, Chengyi — Tianjin Univ. of Tech.

Cervical cancer is one of the most common gynecological malignancies. The colposcope can observe the cervical surface through the microscopic biopsy, which can enhance the diagnosis rate of the cervical cancer and help patients to receive timely and effective treatment. Here, this study combines the deep learning and traditional machine learning algorithm to make the classification of the cervix. Firstly, a series of preprocessing operations are carried out on cervical images, which can improve the accuracy and efficiency of the subsequent cervical classification. Secondly, this study uses the traditional machine learning algorithms and the classical neural network to verify the classification performance of cervical datasets. Thirdly, AlexNet-SVM model uses AlexNet convolutional neural network (CNN) to extract the features of cervical images at the front end, and then input the extracted feature parameters into the support vector machine (SVM) classifier at the back end. Meanwhile, the proposed AlexNet-SVM model utilizes the transfer learning method of freezing convolution layers of the model to improve the classification accuracy. The experimental results show that the accuracy of AlexNet-SVM model is 91.77%, the precision is 93.72%, the sensitivity is 86.15% and the specificity is 95.83%. The current work will be helpful to classify and detect the early cervical lesions.

▷ FriB07-21

Dynamic Obstacle Avoidance Algorithm for Robot Arm Based on Deep Reinforcement Learning

Cheng, Xiaowei — Zhejiang Univ.
Liu, Shan — Zhejiang Univ.

A dynamic obstacle avoidance planning algorithm based on deep reinforcement learning is proposed for rigid manipulators. After the neural network interacts with the environment and learns, it can give real-time action strategies to guide the manipulator to avoid dynamic obstacles. This paper proposes a new state space description method suitable for manipulators and dynamic environments, and designs the corresponding

collision detection method and reward value calculation function for this state description method. The test results in the simulation environment demonstrate the effectiveness of the method.

▷ FriB07-22

An Automatic Reflective Clothing Detection Algorithm Based on YOLOv5 for Work Type Recognition

He, Xinyi	JiangNan Univ.
Ma, Ping	Jiangnan Univ.
Chen, Yiyang	Soochow Univ.
Liu, Yuan	Jiangnan Univ.

At present, traditional manual methods are still utilized for the inspection of reflective clothing on a wide range of construction sites. Using this manual inspection methods wastes much human resource. In this paper, the YOLOv5 model is used as the network framework to automatically detects whether the workers wear reflective clothing, and determines types of work by examining reflective clothing of different colors. By identifying the color difference of the reflective clothing, the network is capable of distinguish whether the target work type can enter relevant construction areas with different danger levels. In this paper, by constructing the labeled data set and training on the basis of YOLOv5 model framework, a target model is obtained. Its detection speed can adapt to real-time monitoring. The accuracy and recall rates can meet the requirements on the training set and verification set. It has a desired effect on the testing set of real website captured images, and can realize the intelligent recognition of reflective clothing on construction sites.

▷ FriB07-23

Attention Based CNN-LSTM Network for Anomaly Pattern Classification of Multivariate Time Series

Zhang, Xian Bo	Jingdongkeji
Wang, Chao	JD Tech.
Zhang, Jing	JD Tech
Lin, Feng	JD.com, Inc
Li, Zezhou	JDTech

Industrial equipment such as server machines, satellites, engines, etc., is monitored with multiple sensors generating multivariate time series (MTS). Tasks like anomaly detection and anomaly pattern classification of MTS, accordingly, are of great importance to fault warning and system stability. Data-driven methods are increasingly becoming prevailing regarding these problems with a huge amount of input information. In this paper, we propose a new architecture where MTS is processed as images and fed into an attention-based CNN-LSTM network (AC-LSTM). CNN-LSTM network is responsible for extracting both spatial and temporal features among and within each dimension of MTS, while the modified attention mechanism helps promote reasonable weight allocations without additional parameters. The proposed model firstly gives anomaly detection and furtherly makes decisions on anomaly classifications if the input is detected as an abnormal one. With the modified attention mechanism and the cooperation of CNN and LSTM, experiments on both public datasets and the operation data collected from real-world applications prove the effectiveness and promotion of the proposed model.

▷ FriB07-24

A Novel Prescribed Performance Control Strategy for Uncertain Nonlinear Systems.

Ju, Jiaying	Shandong Jianzhu Univ.
Liu, Na	Shandong Jianzhu Univ. Architecture & Urban Planning Design Inst.
Liu, Yunlei	Jinan Chengbo Information Tech. Co., Ltd

In this paper, a new finite-time prescribed performance control strategy is proposed for unknown nonlinear systems. Compared with previous research results, the controller is simple in design, with fewer parameters and greatly reduced computational complexity. In addition, the tracking error can relatively quick converge to a predefined performance boundary region in the transient process and remain in this region after reaching the steady state. Finally, the stability analysis and simulation results verify the effectiveness of the proposed controller.

▷ FriB07-25

Output Regulation for Switched Systems: An Event-triggered Model Predictive Control Approach

Guo, Shitong	Shenyang Aerospace Univ.
Qi, Yiwen	Shenyang Aerospace Univ.
Zhang, Simeng	Shenyang Aerospace Univ.
Tang, Yiwen	Shenyang Aerospace Univ.
Yu, Wenke	Shenyang Aerospace Univ.

This paper studies the output regulation problem for switched systems with an event-triggered model predictive control approach. First, an event-triggering strategy is adopted to configure data sampling and communication efficiently. Moreover, the model predictive control approach is considered to optimize the control performance of the closed-loop system. By applying the piecewise Lyapunov function and average dwell time method, sufficient conditions for the solvability of the output regulation problem are given. Then, the design of model predictive controller is transformed into the solution of linear matrix inequalities. Finally, simulation results verify the effectiveness of the proposed method.

▷ FriB07-26

An Improved Multi-agent Based Data Driven Distributed Adaptive Cooperative Control in Traffic Network Signal Timing

Ji, Honghai	North China Univ. of Tech.
Yin, Hu	NCUT
Ren, Ye	Beijing Jiaotong Univ.
Wang, Li	North China Univ. of Tech.
Liu, Shida	Beijing Jiaotong Univ.

For the traffic network signal control scenario, this paper proposes an improve multi-agent data-driven distributed adaptive coordination control algorithm (I-MA-DACC), which outputs the distributed adaptive green time at each intersection for the purpose of dynamic queue balancing. The queuing length obtained by the front-end information collection devices and the green time of the current cycle are the system input and output data, respectively. Meanwhile, queue balancing control of multi-directional traffic flow on signal-controlled traffic networks is considered in the framework of multi-agent system. As a result, the proposed I-MA-DACC is an improved multi-agent based data-driven control strategy.Firstly, the parameter and control learning law are deployed for each intersection enhancing the scalability and adaptive ability. Secondly, the algorithm can be applied to different congestion scenarios in large-scaled traffic network. Finally, it is verified by the Sumo-Python simulation platform with open-source superiority. Compared with other distributed adaptive cooperative control methods, the simulation results show the advantage of I-MA-DACC in reducing of the queuing delays, waiting count and time loss.

▷ FriB07-27

Soft-sensors Based on Gaussian Process Regression for Wastewater Treatment Plants

Liu, Tong	Beijing Univ. of Tech.
Chai, Wei	Beijing Univ. of Tech.
Wang, Congcong	Beijing Univ. of Tech.

For wastewater treatment plants, a large number of process variables are demanded to monitor the operation of the system. Given the problem that some key water quality variables are difficult to get in real-time, a soft-sensor technology is devised to get the value of these variables. For a soft-sensor model, choosing the appropriate input variables will have a great impact on its performance. In this paper, automatic relevance determination (ARD) method which based on Gaussian process regression (GPR) is proposed to select the appropriate input variables. The ARD method considers the nonlinear mapping relationship from input variables to the output variable. Moreover, the wastewater treatment plant is modeled by GPR, which requires fewer model parameters and can give a confidence interval. Finally, an example of the wastewater treatment plant is used to prove the effectiveness of the method.

▷ FriB07-28

Target Controllability of Multi-agent Systems

Ji, Yanan	Qingdao Univ.
Ji, Zhijian	Qingdao Univ.
Liu, Yungang	Shandong Univ.
Lin, Chong	Qingdao Univ.

In this paper, the target controllability of multi-agent systems under directed weighted topology is studied. A graph partition is constructed, in which part of the nodes are divided into different cells, which are selected as leaders. The remaining nodes are divided by maximum equitable partition. By taking the advantage of reachable nodes and the graph partition, we provide a necessary and sufficient condition for the target controllability of a first-order multi-agent system. It is shown that the system is target controllable if and only if each cell contains no more than one target node and there are no unreachable target nodes, with $delta-$reachable nodes belonging to the same cell in the above graph partition. By means of controllability decomposition, a necessary and

sufficient condition for the target controllability of the system is given, as well as a target node selection method to ensure the target controllability. In a high-order multi-agent system, once the topology, leaders and target nodes are fixed, the target controllability of the high-order multi-agent system is shown to be the same to the first-order one. This paper also considers a general linear system. If there is an independent strongly connected component that contains only target nodes and the general linear system is target controllable, then graph $mathcalG$ is leader-target follower connected.

▷ FriB07-29

Wavelet Function Based Spectral Model Calibration for Measuring Crystallization Solution via Using ATR-FTIR Spectroscopy

Pei, Xiaojing	Dalian Univ. of Tech.
Liu, Tao	Dalian Univ. of Tech.
Liu, Jingxiang	Dalian Maritime Univ.
Hao, Shoulin	Dalian Univ. of Tech.
Yang, Siwei	Dalian Univ. of Tech.

For measuring the solution concentration of crystallization process by ATR-FTIR spectroscopy, this paper proposes an improved spectral model calibration method to guarantee in-situ measurement accuracy, based on wavelet function regression. The spectral model structure is composed of wavelet basis functions, which could address the nonlinear properties and high-dimensional problem of infrared spectral variables. Moreover, the mean centralization strategy is taken to reduce the influence from measurement noise. In addition, a comparative study on measuring the solution concentration of the L-glutamic acid (LGA) crystallization process is conducted in terms of using different modeling methods and spectral variables. It is found that the wavelet function regression with all spectral variables could obtain good measurement accuracy compared to the traditional partial least-squares (PLS) method. Experimental results well demonstrate the measurement accuracy of the proposed spectral calibration method.

▷ FriB07-30

Design of Encrypted Secure Wireless Video Real-time Transmission and Storage System Based on 5G Network

Xiao, Hong	Southwest Jiaotong Univ.
Xia, Jingkang	Southwest Jiaotong Univ.
Tang, Guangming	Southwest Jiaotong Univ.
Huang, Deqing	Southwest Jiaotong Univ.

Abstract- In order to ensure the real-time transmission and storage of video data collected by UAV camera and the security of system control commands, an encrypted and secure video transmission and storage system based the on 5G network is studied and designed in this paper. The 5G video transmission device of the system uploads the camera video data to the Linux server in H.264 compression mode and non-compression mode through the 5G network, respectively. The server saves the compressed video data in MP4 format and forwards the non-compression video data to the back-end playback device for real-time playback. The back-end video playback device can also send encrypted control commands to the 5G video transmission device. Finally, from experiments in the 5G SA environment, it can be found that the average transmission rate of uncompressed video data is 109Mb/s, the playback frame rate is 22fps, and the end-to-end playback delay is 51ms. In addition, the server's storage space for storing compressed video data consumes an average of 90Kb/s, and the average transmission delay of the system encryption command is 19ms. These performances meet the application requirements of military UAVs and civilian UAVs.

▷ FriB07-31

Semi-active Suspension Control Strategy of High-speed Train Considering Magnetorheological Dampers

Huang, Deqing	Southwest Jiaotong Univ.
Wang, Xinyue	Southwest Jiaotong Univ.,

As the speed of rail vehicles increases, the phenomenon of lateral vibration of high-speed trains becomes more and more obvious. With the development of magnetorheological damping control technology, active suspension control strategies can be successfully converted and applied to semi-active suspension systems. For the lateral semi-active suspension system based on magnetorheological damper, this paper proposes a control method using a second-order sliding mode to suppress the lateral vibration of high-speed trains. First, the new model of magnetorheological damper integrated high-speed train was introduced. Next, a second-order sliding mode controller is designed based on the 3-degree-of-freedom simulation model to suppress the lateral vibration of the vehicle body. Finally, the input of periodic track irregularities is analyzed. Compared with the passive system, this control strategy can improve the lateral ride comfort of the vehicle.

▷ FriB07-32

Research on Redundant Time Reallocation of Station Based on Minimum Delay

Huang, Deqing	Southwest Jiaotong Univ.
Ni, Chenjia	Southwest Jiaotong Univ.

High-density running of high-speed trains may aggravate train delays. It is of great significance to study how to alleviate the severity of train delays by allocating redundant time reasonably so as to improve train operating efficiency. In this paper, a redundant time redistribution scheme with multiple station delays is proposed, which takes the station delay as the delay state and minimizes the total delay expectation. Through the analysis and validation of the delays data of the three stations on the Beijing-Guangzhou high-speed railway, it is found that the proposed method reduces the total delay expectation by 7.26% and reduces the train group delays to a certain extent, which proves the validity of this scheme.

▷ FriB07-33

Bipartite Tracking Consensus for Multi-Agent Systems with Input Delays and Nonlinear Dynamics

Du, Xiangyang	Tianjin Univ. of Tech. & Education
Li, Weixun	Tianjin Univ. of Tech. & Education
Zhang, Liqiong	Tianjin Univ. of Tech. & Education
Zhang, Limin	Zhongyuan Univ. of Tech.

This article is devoted to the bipartite tracking consensus for multi-agent systems with control input delay and nonlinear dynamics under directed signed graph. Based on the relative messages of the agents' neighbors, a distributed control protocol is designed to make the systems achieve bipartite consensus in the presence of a single leader. For the sake of dealing with the nonlinear function, the reduction transformation is applied. Via Lyapunov stability theory, the sufficient conditions which guarantee the multi-agent system reach bipartite consensus. And finally, the simulations are given to verify the effectiveness of the results in the paper.

FriC01 13:30–15:30 Room 1

Invited Session: Data-Driven Adaptive Learning Control for Nonlinear Systems (I)

Organizer: Wang, Shubo	Qingdao Univ.
Organizer: Na, Jing	Kunming Univ. of Sci. & Tech.
Organizer: Chen, Qiang	Zhejiang Univ. of Tech.
Chair: Wang, Shubo	Qingdao Univ.
Co-Chair: Na, Jing	Kunming Univ. of Sci. & Tech.

▶ FriC01-1 13:30–13:50

Multi-innovation Parameter Identification Based on Coupling Auxiliary Model for Three-axis Turntable

Wang, Minlin	Beijing Inst. of Tech.
Dong, Xueming	Department of Inertia
Ren, Xuemei	Beijing Inst. of Tech.

This paper proposes an multi-innovation identification algorithm based on coupling auxiliary model for the three-axis turntable system. By introducing a shift operator, the hierarchical model of three-axis turntable is established and then transformed into three sub-identification models, which can reduce the computation complexity. With the help of coupling auxiliary model, a recursive least squares identification algorithm is designed for the sub-identification models to identify the system parameters. To further improve the convergence speed of identification process, a multi-innovation recursive identification algorithm is developed by using multi-step update principle to solve the multi-innovation length problem and achieve the fast identification for three-axis turntable. Experimental results based on a three-axis turntable is conducted to demonstrate the effectiveness of the proposed identification algorithm.

▶ FriC01-2 13:50–14:10

Trajectory Tracking Control of Nonlinear Singularly Perturbed Systems with Disturbances

Zheng, Dongdong	Beijing Inst. of Tech.
Li, Weixing	Beijing Inst. of Tech.
Ren, Xuemei	Beijing Inst. of Tech.

In order to solve the control problem of singularly perturbed systems subject to external disturbances, a novel composite control scheme based on the disturbance observer and the singular perturbation technique is proposed. To reduce the system order and facilitate the controller de-

sign, the singular perturbation technique is first utilized to decompose the original high-order system into two lower order subsystems. Subsequently, nonlinear disturbance observers are proposed for reduced order slow subsystem and the reduced order fast subsystem respectively. Using the estimated disturbance information, two composite controllers are developed for the reduced-order subsystems, and the uniformly ultimately boundedness of subsystems is guaranteed. Moreover, the stability of the closed-loop high-order system is also proved via the Lyapunov approach, even though the observers and controllers are developed for the reduced-order subsystems. The effectiveness of the proposed control scheme is demonstrated by simulations.

▶ FriC01-3 14:10–14:30

Adaptive Estimation for Quantized Nonlinear Cascade System

Li, Linwei — Zhengzhou Univ. of Light Industry
Wang, Fengxian — Zhengzhou Univ. of Light Industry
Ren, Xuemei — Beijing Inst. of Tech.

In this paper, we introduce an adaptive estimation method for quantized nonlinear cascade system using moving window theory. Firstly, by force of the sub-decomposition technique, the considered system is transformed to a regression model without product term, in which the computational complexity is reduced. Secondly, by developing a moving window, the moving window output and moving window observation data are constructed, in which the estimation accuracy is lifted. Then, based on moving data, a filter is introduced to filter noise data, and to improve the bias estimation issue. Thirdly, by designing the forcing variables with adaptive attenuation coefficient, the estimation error data can be got which is used to develop estimator, in which it gives an optional scheme to design the adaptive estimator compared with the prediction error and observation error criterion. Finally, the example results demonstrate that the developed method is effective to achieve the parameter estimation for quantized nonlinear cascade system, and has better performance compared with some estimators in term of estimation precision and convergence rate.

▶ FriC01-4 14:30–14:50

Adaptive Optimal Controls for Multi-Driving Gear of Long-Wall Shearer

Li, Zhien — TISCO Electric Co.,Ltd
Zhao, Jun — Kunming Univ. of Sci. & Tech.
Jian, Long — Taiyuan Univ. of Tech.
Lv, Yongfeng — Taiyuan Univ. of Tech.

The conventional coal miner cut-off section uses a single-motor system, which will stall when encountering a hard header surface due to power limitations. In this paper, we improve the multi-motor servo system of coal miner cut-off section and propose an adaptive optimal controller for multi-drive coal miner servo system. The gear power can be changed to be lager with the multi-driver servo motor, which can cut the hard header coal surface effectively. Firstly, the coal miner multi-driven servo system is approximated a neural network. Then, define the optimal performance index with the coal miner servo system states and torques. The adaptive torques are found using an approximation dynamic programming (ADP) technique based on a given performance function that can find the saddle point and minimize the coal miner performance index. The NN weights' convergence is investigated. Finally, a simulation is included to demonstrate the efficacy of the strategies for optimizing coal miner servo system performance.

▶ FriC01-5 14:50–15:10

Finite-Time Approximation-Free Control for Attitude Tracking of Rigid Spacecraft

Xie, Shuzong — College of Information Engineering, Zhejiang Univ. of Tech.
Chen, Qiang — Zhejiang Univ. of Tech.
He, Xiongxiong — Zhejiang Univ. of Tech.
Ou, Xianhua — Zhejiang Univ. of Tech.

In this paper, a finite-time command-filtered approximation-free attitude tracking control strategy is proposed for rigid spacecraft. A novel finite-time prescribed performance function is first constructed to ensure that the attitude tracking errors converge to the predefined region in finite time. Then, a finite-time error compensation mechanism is constructed and incorporated into the backstepping control design, such that the differentiation of virtual control signals in recursive steps can be avoided to overcome the singularity issue. Compared with most of approximation-based attitude control methods, less computational burden and lower complexity are guaranteed by the proposed approximation-free control scheme due to the avoidance of using any function approximations. Simulations are given to illustrate the efficiency of the proposed method.

▶ FriC01-6 15:10–15:30

Hybrid Unscented Kalman Filter Design with Data-driven Schedule

Li, Gengen — Kunming Univ. of Sci. & Tech.
Yang, Chunxi — Kunming Univ. of Sci. & Tech.
Gao, Guanbin — Kunming Univ. of Sci. & Tech.
Han, Shichang — Kunming Univ. of Sci. & Tech.
Chen, Fei — Kunming Univ. of Sci. & Tech.

This paper studies the filter design of grey system based on random forest model. Firstly, the unknown dynamic part of the grey system is modeled by using the random forest machine with particle swarm optimization (Random forest machine with improved fruit fly optimization algorithm, IFOA-FR). Then, the unknown dynamic model is compensated into the design of unscented Kalman filter to obtain the unscented Kalman filter of grey system. Finally, a reentry target state estimation is used for numerical simulation to verify the effectiveness of unscented Kalman filter of grey system based on random forest.

FriC02 13:30–15:30 Room 3

Regular Session: Deep Neural Network and Reinforcement Learning Control

Chair: Song, Ruizhuo — Univ. of Sci. & Tech. Beijing
Co-Chair: Shi, Jia — Xiamen Univ.

▶ FriC02-1 13:30–13:50

A Hybrid Deep Learning Model for the Blood Glucose Prediction

Lu, Xiang — Univ. of Sci. & Tech. Beijing
Song, Ruizhuo — Univ. of Sci. & Tech. Beijing

Blood glucose (BG) control is important for diabetics to avoid hyperglycemia and hypoglycemia events in their daily life. And the forecasting of BG becomes one of the most important sections of the blood glucose control system. Accurate prediction makes patients can react to the abnormal values in advance so that precisely controlling their BG level can be realized. In this study, we propose a novel method to predict BG levels for 30 min of prediction horizon (PH) with a hybrid deep learning model, which integrates multi-layer perceptron, stacked bidirectional gated recurrent unit (Bi-GRU) based recurrent neural network (RNN), and the attention mechanism (AM). Firstly, after pre-processing, the real patient data (in this work, the history BG only) as the input is transmitted to the network used for training and testing. Subsequently, the stacked Bi-GRU layers are used for extracting temporal characteristics of time sequence data, the AM is used for paying more attention to the temporal information which has higher relevance with outputs by assigning weights and then multi-layer perceptron for rapid gradient descent and calculating the regression output of our neural network (in this work, the predict BG). Finally, some important criteria of predictive evaluation are used to demonstrate the effect of our method.

▶ FriC02-2 13:50–14:10

Two Dimensional (2D) Feedback Control Scheme Based on Deep Reinforcement Learning Algorithm for Nonlinear Non-repetitive Batch Processes

Liu, Jianan — Xiamen Univ.
Hong, Wenjing — Xiamen Univ.
Shi, Jia — Xiamen Univ.

The repetitive/periodic/batch process is widely used in modern industrial production. However, in the context of complex batch processes with nonlinear and non-repetitive nature, designing an effective control scheme is still a critical problem in theoretical research and practical application. In terms of the excellent performance of deep reinforcement learning (DRL) in dealing with the decision-making problems for complex dynamical systems and interacting without any requirement of prior knowledge of the processes, in this paper, we propose a model-free controller design scheme by using soft actor-critic (SAC), an advanced off-policy DRL algorithm. By properly designing the state information, the neural network structure of the policy, and the reward function, the SAC agent is trained as a nonlinear two-dimensional (2D) state feedback control to achieve high tracking performance and strong robustness for the nonlinear non-repetitive batch processes. Our simulation results demonstrate the proposed control method' s effectiveness and applicability, and its significant performance is superior to the conventional iterative learning control (ILC) schemes.

▶ FriC02-3 14:10–14:30

SIM: A Scenario IMagination Based Deep Reinforcement Learning Method for Outdoor Transportation Environment Exploration

Li, Haoran — Univ. of Chinese Acad. of Sci.

Zhang, Qichao Chinese Acad. of Sci.
Chen, Yaran Chinese Acad. of Sci.
Zhao, Dong-Bin Inst. of Automation

Autonomous exploration is very important for robotics, especially for mapping, navigation, and planning in an unknown environment. In recent years, automatic exploration methods in the indoor environment have been extensively studied, but there is little research on exploration in the outdoor transportation environment. Due to the limitations of outdoor traffic rules and the scale of the environment, the methods for the indoor environment are difficult to apply to the transportation environment. Aiming at exploration in the transportation environment, this paper proposes a deep reinforcement learning algorithm based on Scenario IMagination(SIM), which has two important components: 1) a mid- level action space, which combines the classical robot control algorithm, addressing the inefficient learning and unstable nav- igation of deep reinforcement learning algorithms in automatic exploration. With this action space, the deep reinforcement learning algorithm achieves excellent exploration performance in both normal scale environments and large-scale branchless environments; 2) a scenarios buffer, which relieves hard explo- ration problems of deep reinforcement learning due to serious imbalances of samples in large-scale multibranch scenarios. Compared to the mapless navigation approaches, SIM achieves excellent exploration performance in large-scale multi-branch environments.

▶ FriC02-4 14:30–14:50

Nonlinear Approximate Optimal Control Based on Integral Reinforcement Learning

Tian, Fenming Jiangnan Univ.
Liu, Fei Jiangnan Univ., China

This paper aims to find the optimal control solution of an affine nonlinear continuous-time system with unknown input dynamic. Based on Critic-Actor neural network, an online integral reinforcement learning algorithm has been proposed. The algorithm solves the Bellman equation online, while Critic neural network is used to approximate the value function and Actor neural network is used for policy improvement. The policy evaluation and policy improvement of integral reinforcement learning are performed alternately until the performance of control systems no longer improves. By using Lyapunov function theory, all the weights of Critic-Actor neural network and the states of the system are guaranteed to be locally uniformly ultimately bounded. The simulation results show the effectiveness of the developed method.

▶ FriC02-5 14:50–15:10

Neural Network-based Adaptive Sliding Mode Control for Cricket Systems

Sun, Chuanbin Qingdao Univ.
Wang, Shubo Qingdao Univ.
Liu, Yi-Jian Qingdao Univ.

The cricket system is a multivariate, strongly coupled, nonlinear control object. However, the unknown friction, interior and exterior disturbances, and parameter uncertainties in the cricket system can reduce the control performance. To tackle the above problems, an adaptive neural network -based sliding mode control strategy is proposed for the built three-degree-of-freedom parallel mechanism cricket ball system. Firstly, the mathematical model of the cricket system was built by the usage of Lagrange's kinematic equations. Secondly, the cricket system model is decoupled into two parts via geometric relations: linear and nonlinear parts. A sliding mode variable structure control method is proposed for the linear part. The hassle of large control errors and inaccurate trajectory monitoring during system operation is solved by using the nice robustness and the anti-interference property of sliding mode control. For the unknown perturbations and system friction in the nonlinear part, a combination of neural network based adaptive control is used for error estimation compensation. The system stability of the closed-loop system is analyzed using Lyapunov stability theory. Finally, the effectiveness of the algorithm is confirmed by simulation and experiment. The simulation results show that the improved sliding mode controller has a better control effect for the cricket system with smaller manipulate errors and more accurate trajectory tracking. The fixed-point control experiment is completed in the built cricket ball system, and the trajectory image of the ball is drawn with the experimental data. The consequences show that the improved control algorithm improves the trajectory monitoring control accuracy and can ensure the monitoring control of the cricket ball system with higher stability and convergence speed.

▶ FriC02-6 15:10–15:30

Distributed Q-Learning for Stochastic LQ Control with Unknown Noise

Zhang, Zhaorong The Hong Kong Polytechnic Univ.
Xu, Juanjuan Shandong Univ.

This paper studies a discrete-time stochastic control problem with linear quadratic criteria over an infinite-time horizon. We focus on a class of control systems whose system matrices are associated with random parameters involving unknown statistical properties. In particular, we design a distributed Q-learning algorithm to tackle the Riccati equation and derive the optimal controller stabilising the system.

FriC03 13:30–15:30 Room 4

Invited Session: Data-driven Modeling and Adaptive ILC

Organizer: Chen, Qiang Zhejiang Univ. of Tech.
Organizer: Kong, Ying Zhejiang Univ. of Tech.
Organizer: Li, He Zhejiang Univ. & Tech.
Organizer: Yan, Qiuzhen Zhejiang Univ. of Water Resources & Electric Power
Chair: Chen, Qiang Zhejiang Univ. of Tech.
Co-Chair: Wei, Qinglai Inst. of Automation

▶ FriC03-1 13:30–13:50

A Repeatable Motion Scheme for Kinematic Control of Redundant Manipulators

Zhou, Junwen Zhejiang Univ. of Sci. & Tech.
Wu, Jiajia Zhejiang Univ. of Sci. & Tech.
Chen, Shiyong Zhejiang Univ. of Sci. & Tech.
Kong, Ying Zhejiang Univ. of Tech.

To achieve the closed trajectory motion planning of redundant manipulators, each joint angle has to return to its initial position. Most of the repeatable motion schemes have been proposed to solve the problems only considering the joint angles of the manipulators are in the desired initial position at first. Actually, it is very difficult for various joint angles of the robot arms to be positioned in the expected trajectory before moving. To construct a effective kinematic model, a novel optimal programming index is designed and analysed in this paper, of which the repetitiveness and timeliness are presented by using a terminal recurrent neural network method. Combing the programming index, a repeatable motion scheme is proposed with robot kinematic equation constraints, which is reformulated like a quadratic programming (QP). In addition, theorems with the lagrange multiplier algorithm prove that such a repeatable motion scheme can be converted into a time-varying linear equation. A neural solver based on terminal recurrent neural networks is constructed for the solution of motion scheme. Two different trajectories visualize the accuracy and timeliness of this motion scheme. Finally, comparisons for different repetitive schemes are verified the optimal time for joints backing with the proposed novel scheme.

▶ FriC03-2 13:50–14:10

CCANet: Classifcation of Colorectal Tumor Histopathological Images Using A CNN with Channel Attention Mechanisms

Zhang, Licheng Zhejiang Univ. of Tech.
Cao, Fakun Zhejiang Univ. of Techonology
Cao, Jing Zhejiang Univ. of Tech.
Zhu, Beibei Zhejiang Univ. of Tech.
Li, Sheng Zhejiang Univ. of Tech.
He, Xiongxiong Zhejiang Univ. of Tech.

Colorectal cancer is one of the most common malignant tumors, for which histopathological image analysis is the gold diagnosis standard. Nevertheless, the diagnostic process of organizing images is time-consuming and laborious. So a fast and effective computer automatic analysis method is needed. Convolutional Neural Networks (CNN) are widely used for various cancer classification tasks. Still, the image's potential global and channel relationship may be ignored and affect the feature representation ability. Also, the results are often not convincing for pathologists due to the un-interpretability. We propose a lightweight colorectal tumor classification network with only 10.02M parameters based on CNN and Channel Attention Mechanisms. The four classification tasks performed on the public dataset Warwick_qu reached an accuracy of 80.49%. In addition, the visual analysis of Grad_CAM reasonably interprets the results to make it more convincing for pathologists.

▶ FriC03-3 14:10–14:30

An Adaptive Integral Sliding Mode Control with Allocation Scheme for Reconfigurable Flight Array

Yang, Jianquan Kunming Univ. of Sci. & Tech.
Yang, Chunxi Kunming Univ. of Sci. & Tech.
Na, Jing Kunming Univ. of Sci. & Tech.
Li, Yiming Kunming Univ. of Sci. & Tech.
Xing, Yashan Kunming Univ. of Sci. & Tech.

This paper proposes a tracking control strategy for a reconfigurable flight array system with varible configuration. The presented control scheme does not dependent on the accurate mathematical model of system. By employing a pseudo-inverse method with the control efficiency matrix, an control allocation method is constructed to achieve trajectory tracking for a multi-configuration flight array system. To maintain the trajectory tracking performance, an adaptive integral sliding mode controller is designed by using the distance information of the sliding variables and the boundary layer. Theoretical analysis is studied in terms of the Lyapunov theory. Finally, comparative simulation results are provided to demonstrate the effectiveness of the proposed method.

▶ FriC03-4 14:30–14:50

Adaptive Iterative Learning Control for Electromechanical Systems Performing Iteration-varying Tasks

Shi, Huihui Zhejiang Univ. of Tech.
Chen, Qiang Zhejiang Univ. of Tech.
He, Xiongxiong Zhejiang Univ. of Tech.
Ou, Xianhua Zhejiang Univ. of Tech.

In this paper, an adaptive iterative learning control scheme is presented for error tracking of the electromechanical system performing iteration-varying tasks with unknown uncertainties. In order to deal with the initial condition problems including iteration-varying initial state and iteration-varying tasks, a desired error trajectory is constructed with requiring few factors in the trajectory construction, such that the system output can track the iteration-varying reference trajectory over a finite time interval. Then, RBF neural networks are utilized to compensate for the system uncertainties including hysteresis nonlinearity, and the unknown parameters are updated by designing combined adaptive learning laws. Finally, rigorous stability analysis of the closed-loop system and the tracking error convergence are provided through constructing integral Lyapunov-like functions.

▶ FriC03-5 14:50–15:10

Adaptive Iterative Learning Control for Nonlinear Systems with Time-Iteration-Varying Parametric Uncertainties and Nonparametric Uncertainties

Hong, Zheng Zhejiang Univ. of Water Resources & Electric Power
Yan, Qiuzhen Zhejiang Univ. of Water Resources & Electric Power
Cai, Jianping Zhejiang Univ. of Water Resources & Electric Power
Chen, Qiang Zhejiang Univ. of Tech.

This work studies the adaptive ILC algorithm for nonlinear systems with nonparametric uncertainty and time-iteration-varying parametric uncertainty generated from a high-order internal model(HOIM) under nonzero initial errors condition. We apply time-varying boundary layer technique to deal with the initial position problem of ILC, adopt robust learning control approach to compensate nonparametric uncertainty, and take advantage of adaptive learning strategy to handle the time-iteration-varying parametric uncertainty generated from HOIM. The controller design and convergence analysis of closed-loop system will be carried out by using Lyapunov synthesis method. As the iteration number increases, the filtering error can converge to a tunable residual set. An example is provided to show the effectiveness of propose adaptive learning control scheme.

▶ FriC03-6 15:10–15:30

Data-Driven Optimal Control for Half-Vehicle Suspension System via Adaptive Dynamic Programming

Li, Hongyang Chinese Acad. of Sci.
Wei, Qinglai Inst. of Automation

In this paper, a data-driven optimal control method is provided for the half-vehicle suspension system via adaptive dynamic programming. The main contribution of this paper is that the data-driven adaptive dynamic programming method is applied to the optimal control problem of half-vehicle suspension system, which only requires the input-state data of the system. First, the structure of the half-vehicle suspension system is analyzed, and the optimal control problem is introduced. Next, the model-based adaptive dynamic programming method is provided. Based on the model-based method, a data-driven adaptive dynamic programming method is given. The properties of the provided methods are analyzed. Finally, simulation example is given to show the effectiveness of the data-driven adaptive dynamic programming method.

FriC04 13:30–15:30 Room 5

Invited Session: RNN for Signal Processing and Its Applications

Organizer: Sun, Zhongbo Changchun Univ. of Tech.
Organizer: Shi, Yang Yangzhou Univ.
Organizer: Jin, Long Lanzhou Univ.
Chair: Sun, Zhongbo Changchun Univ. of Tech.
Co-Chair: Jin, Long Lanzhou Univ.

▶ FriC04-1 13:30–13:50

Path Planning for Upper Limb Rehabilitation Based on Human Motion Feature Output

Yan, Yangben Changchun Univ. of Tech.
He, Tianyu Changchun Univ. of Tech.
Liu, Yongbai Changchun Univ. of Tech.
Wang, Gang Changchun Univ. of Tech.
Liu, Keping Changchun Univ. of Tech.
Sun, Zhongbo Changchun Univ. of Tech.

A method based on inherent characteristics and output functions of upper limb movement is utilized to construct an optimal path for upper limb rehabilitation. According to the collected movement data of upper limb, a two-dimensional representation of the upper limb movement is generated for finding human kinematics outputs as inherent characteristics. Moreover, an output function is obtained via processed human kinematics outputs which can be described movement with a height fit of the upper limb movement trajectory. To obtain the optimal upper limb rehabilitation training path, the rehabilitation exercise index based on ergonomics is designed to constrain the collected human motion data. The golden section algorithm is used to calculate the constrained human output data, and the final human body canonical output function Obtained by Fourier fitting. The canonical output functions based on human output is applied to the path planning of the rehabilitation robot. The simulations and results show that the canonical output function improves the efficiency of rehabilitation training and ensures effectiveness and comfort for upper limb rehabilitation.

▶ FriC04-2 13:50–14:10

Rehabilitation Path Planning Based on Human Motion Output and Ergonomic Index Optimization

He, Tianyu Changchun Univ. of Tech.
Yan, Yangben Changchun Univ. of Tech.
Wang, Gang Changchun Univ. of Tech.
Liu, Yongbai Changchun Univ. of Tech.
Liu, Keping Changchun Univ. of Tech.
Sun, Zhongbo Changchun Univ. of Tech.

The challenge of motion path planning for rehabilitation training is proposed based on the requirements of human simulation and comfort during the motion of rehabilitation robots. The normalized output function for human-like path planning is obtained, which is based on the inherent virtual constraints or output of the human lower limb, and the constraints are optimized through ergonomic index. First, the human body output data of the subject is collected through the optical motion capture system, after that the original normalized output function is obtained by Fourier fitting, and then the constraints are based on ergonomic indicators. Second, the constrained human body output data is calculated by the golden section algorithm, and finally the final human body standardized output function is obtained by Fourier fitting. Last, the standardized output function based on human output is applied in the path planning of rehabilitation robots, which can make the training of rehabilitation robots have a higher degree of human simulation and comfort, so as to achieve better rehabilitation effect.

▶ FriC04-3 14:10–14:30

Performance Analyses of Discrete-Time RNN for Solving Discrete-Form Time-Variant Matrix Inversion with Different Selection Parameters

Shi, Yang Yangzhou Univ.
Fu, Shengshen YangzhouUniv.
Ding, Chenling Yangzhou Univ.
Li, Jian Xinyang Normal Univ.
Gerontitis, Dimitrios Aristotle Univ.

Neural network could be considered as a basic artificial intelligence methods. In this paper, we explore a lot of researches on performance analyses of discrete-time recurrent neural network (DT-RNN) model. For solving the discrete-form time-variant matrix inversion (DF-TV-MI),

continuous-time recurrent neural network (CT-RNN) model is presented firstly. Then, an inspirational method named general-four-instant discretization formula (GFI discretization formula) to discrete the CT-RNN model, and we obtain a new DT-RNN model. Finally, we show the performance analyses of DT-RNN model solving for DF-TV-MI with different selection parameters.

▶ FriC04-4 14:30–14:50

Discrete-time Recurrent Neural Network Algorithm with Different Discretization Formulas for Finding Solution of Discrete-Time Complex Division

Shi, Yang	Yangzhou Univ.
Lu, Jiwen	Yangzhou Univ.
Zhao, Wenhan	Yangzhou Univ.
Sheng, Wangrong	Yangzhou Univ.
Li, Jian	Xinyang Normal Univ.
Gerontitis, Dimitrios	Aristotle Univ.

In this paper, in order to solve discrete-time complex division, we propose several discrete-time recurrent neural network (DT-RNN) algorithms. First of all, the continuous-time complex division is transformed into matrix equation equivalently, which can be solved by the continuous-time recurrent neural network (CT-RNN) algorithm. Secondly, several discretization formulas developed by Taylor formula are used to establish the corresponding DT-RNN algorithms. Finally, numerical experiments are carried out, which present the feasibility and effectiveness of these DT-RNN algorithms.

▶ FriC04-5 14:50–15:10

Kinematics Solution Analysis of 6R Robot Based on Spinor Exponential Product

Zhang, Ziqiang	Changchun Univ. of Sci. & Tech.
Cao, Guohua	Changchun Univ. of Sci. & Tech.
Li, Xiaozhou	Changchun Univ. of Sci. & Tech.
Zhang, Bangcheng	Changchun Univ. of Tech.

Abstract: In the kinematics research of multi-degree-of-freedom robots, D-H(Denavit-Hartenber) parametric modeling is the most commonly used. However, the D-H parameter method needs to establish a complex coordinate system relationship, and it is difficult to avoid singular solutions. To solve these problems, a new forward and inverse motion solution method based on the exponential product form of the spinor theory is proposed. In the model, the rigid body motion equation based on the spinor theory is described based on the Plücker coordinate system. And a mathematical model for the robot's forward kinematics that is based the product of the spinor and the exponential is proposed. Based on the mathematical model of positive kinematics, the derivation operation is used to construct the inverse kinematics equation of the robot, and solve the complex multivariate equation system expanded by inverse kinematics. The mathematical symbolic operation method combined with MAPLE and MATLAB is used to solve the complex multivariate equations in inverse kinematics, and avoid the complexity of the Paden-Kahan subproblem process used in inverse kinematics based on spinor theory. The kinematics analysis and solution of the KUKA-KR5 arc 6R robot are carried out by the proposed method of rotational volume exponential product modeling. Through example calculation, the correctness and effectiveness of the proposed forward and inverse kinematics solution algorithm are verified.

▶ FriC04-6 15:10–15:30

Dynamic Fault Detection Based on Variational Bayesian Mixture Probabilistic Principal Component Analysis

Huang, Chenghong	ChongQing Univ.
Chai, Yi	Chongqing Univ.
Wei, Chihang	Hangzhou Normal Univ.
Zhu, Zheren	Zhejiang Univ.

It is essential to achieve real-time fault detection of the industrial process to reduce the occurrence of accidents during the industrial process. However, there are some problems in the actual monitoring process, such as the instability of sensor measurement, losing packet while transferring data, which causes problems like missing data and outliers while sampling from actual monitoring data. In addition, the monitoring data are interrelated in time series. Thus, a fault detection method based on DMPPCA model is proposed in this study. DMPPCA can not only consider the above problems at the same time, but also determine the dimension of latent variables automatically. Finally, the effect of proposed DMPPCA model was validated by a three-phase flow facility.

FriC05 13:30–15:30 Room 6

Invited Session: Data-driven Virtual-sensor: Algorithm, Architectures and Applications

Organizer: Zhang, Xinmin	Zhejiang Univ.
Organizer: Zhou, Le	Zhejiang Univ. of Sci. & Tech.
Chair: Zhang, Xinmin	Zhejiang Univ.
Co-Chair: Zhou, Le	Zhejiang Univ. of Sci. & Tech.

▶ FriC05-1 13:30–13:50

Deep Learning of Process Data with Supervised Variational Autoencoder for Soft Sensor

Tang, Xiaochu	Shenyang Aerospace Univ.
Yan, Jiawei	Shenyang Aerospace Univ.
Song, Zhihuan	Zhejiang Univ.
Zhang, Xinmin	Zhejiang Univ.

Nonlinearity and uncertainty are two critical characteristics when process data modeling is applied to soft sensor. In this paper, a supervised variational auto-encoder (SVAE) is developed to capture both nonlinear and untcertain feature for regression modeling. SVAE, as a deep generative model, provides a probabilistic framework, based on which the deep nonlinear feature extraction is carried out and a probabilistic respresentation can be obtained. In this way, the probability distribution mapping from process variables to the key quality variables is learned so that quality prediction can be well achieved. The feasibility of the proposed method is illustrated by a numerical example and an industrial example, and the effectiveness of the proposed model is verified by comparing with the linear model.

▶ FriC05-2 13:50–14:10

Yarn-dyed Shirt Piece Defect Detection Based on U-shaped Swin Transformer Auto-encoder

Zhang, Hongwei	Zhejiang Univ.
Xiong, Wenbo	Xi'an Polytechnic Univ.
Zhang, Weiwei	Xi'an Polytechnic Univ.
Lu, Shuai	Beijing Univ. of Chemical Tech.

Automatic defect detection is an essential and challenging problem in the yarn-dyed weaving production process, this paper proposed a novel U-shaped Swin Transformer auto-encoder reconstructed model for yarn-dyed shirt piece defect detection. This method uses the model of Transformer to extract the global features of the image better and reconstruct it more accurately, which solves the problems of scarce and unbalanced type of defect samples and high cost in actual production. Firstly, for a certain pattern, using defect-free samples adding Gaussian noise to train the reconstruction model. Then, the image to be tested is input into the Transformer model to obtain the corresponding output image. Subsequently, the residual image is calculated by subtracting the input image and its corresponding output image. Finally, the defect localization can be achieved through thresholding and morphological operation. The experiment result verifies the effectiveness of the proposed method on various types of yarn-dyed shirt pieces.

▶ FriC05-3 14:10–14:30

Novel Multimode Process Soft Sensing Methods Based on the Dynamic Mixture Variational Autoencoder Regression Model

Cui, Linlin	Zhejiang Univ.
Yao, Le	Zhejiang Univ.
Ge, Zhiqiang	Zhejiang Univ.
Song, Zhihuan	Zhejiang Univ.

Modern industrial processes with increasing complexity not only contain nonlinear and multi-mode characteristics, but also are commonly the dynamic processes, which brought challenging problems to soft sensor modeling. In order to solve these problems, a dynamic mixture variational autoencoder regression (DMVAER) model is proposed for the nonlinear multi-mode modeling, which is suitable for industrial process quality prediction with multiple complex process characteristics. Furthermore, in order to deal with the problem of semi-supervised data with a large number of unlabeled samples, a semi-supervised dynamic mixture variational autoencoder regression (ssDMVAER) model is proposed, and the corresponding semi-supervised data sequence division method is adopted to make full use of the information in both labeled data and unlabeled data. Finally, in order to verify the feasibility and effectiveness of the proposed methods, the two models are applied to an actual industrial process of methanation furnace. The results show that the proposed methods have superior soft sensing performance than existing methods.

▶ FriC05-4 14:30–14:50

Stacked Denoising Autoencoders Based Poisson Regression for Count

Data Modeling

Zhang, Xinmin Zhejiang Univ.
Liu, Ying Zhejiang Univ.
Song, Zhihuan Zhejiang Univ.
Zhu, Zheren Zhejiang Univ.
Wei, Chihang Hangzhou Normal Univ.

Data-driven virtual-sensors or soft-sensors are important tools for predicting quality variables or KPIs in many industrial processes. However, the existing virtual-sensors models are generally based on the assumption that the response variable or model error structure satisfies normality and homoscedasticity. But, in many practical applications, the response variable of interest is a nonnegative integer or count that we want to model or analyze based on a set of explanatory variables. The count data usually violate these assumptions and exhibit heteroscedasticity and skewed distribution. To model and analyze count data, this paper proposes a stacked denoising autoencoders-based Poisson regression (SDAE-PR) model. In SDAE-PR, the stacked denoising autoencoders are adopted to extract the high-level feature representation of the data, and Poisson regression is then performed on this representation. Unlike the conventional Poisson regression model which use hand-crafted features to build the model, SDAE-PR can extract high-level feature representations, which not only helps to improve the prediction accuracy of the Poisson regression model, but also is more robust to noise; In addition, SDAE-PR inherits the merits of Poisson regression that can ensure the non-negativity for the prediction of the response variable, which is a key for the count data modeling and analysis. The experimental results demonstrated that the proposed SDAE-PR model is more accurate than the other state-of-the-art methods in terms of prediction accuracy.

► FriC05-5 14:50–15:10

Distributed Linear Dynamical System for Learning from Massive and Inconsecutive Time-Series Data and Its Application to Industrial Predictive Modeling

Shao, Weiming China Univ. of Petrolieum

Linear dynamical system (LDS) has established itself as a powerful paradigm for developing predictive models for dynamic industrial processes, which however still faces some practically pivotal yet intractable issues. Firstly, massive time-series data render significant computational deficiency in training an LDS model, and such issue gets considerably aggravated by optimizing the variable time delays that usually cannot be ignored in industrial processes. Secondly, due to the malfunctions of data communication system or measurement sensors, the time-series data chain is often broken, which generates inconsecutive time-series data. That is, inconsecutive time-series data are have to be dealt with. Unfortunately, the presently available algorithms for LDS model training fail to learn from inconsecutive time-series data, resulting in degraded performance. To deal with these tough problems, this paper proposes a distributed learning algorithm for the LDS (referred to as 'DisLDS') in semisupervised scenario. In the DisLDS, time-series data are artificially or naturally divided into multiple consecutive blocks, and an efficient learning algorithm is designed to extract patterns from these data blocks in the mode of parameter server, such that distributed computing is realized and mining all available data is enabled. Case studies are conducted on a real-life industrial process for evaluating the performance of the DisLDS. The results demonstrate that the DisLDS could significantly improve the computational efficiency and in the same time achieve superior or comparative predictive accuracy.

► FriC05-6 15:10–15:30

Layer-wise Feature Extraction Approaches with Deep PLS for Quality Prediction in Industrial Process

Yuan, Xiaofeng Zhejiang Univ.
Xu, Weiwei Central South Univ.
Wang, Kai Central South Univ.
Wang, Ya-Lin Central South Univ.

Partial least squares (PLS) has been widely applied for quality prediction in industrial processes. However, PLS can only extract one-layer linear quality-relevant features for regression tasks. Besides, shallow PLS suffers from information loss in its residual subspace. To alleviate these problems, a deep PLS (DPLS) framework and its enhanced version are proposed in this paper. DPLS consists of multi-layer PLS and uses the extracted features as layer connection. To improve model nonlinearity, nonlinear functions are introduced between two adjunct layers. With layer-wise nonlinear mappings and PLS, more high-level and quality-related features can be mined and utilized for soft sensor modeling. On this basis, an enhanced DPLS (EDPLS) method is further developed to make full use of information in residual PLS by considering it in the next layer. Finally, the effectiveness of the proposed methods is validated on an industrial hydrocracking process.

FriC06 13:30–15:30 Room 7

Regular Session: ADRC and Robust Control

Chair: Chen, Sen Shaanxi Normal Univ.
Co-Chair: Xue, Wenchao Chinese Acad. of Sci.

► FriC06-1 13:30–13:50

A Robust Control Scheme for Autonomous Vehicles Path Tracking under Unreliable Communication

Zhang, Kun Acad. of Mathematics & Sys. Sci., Chinese Acad. of Sci.
Zhang, Huaguang Northeastern Univ., China
Xue, Wenchao Chinese Acad. of Sci.
Zhang, Ran Beihang Univ.

This paper investigates the intelligent driving control problem for a class of autonomous vehicles by using a policy iteration method. Firstly, we analyze the autonomous vehicle's motion with respect to its linear and rotational velocities under unreliable communication. By this way, the dynamic function based on kinematic equation is built, then, combining the desired reference and the autonomous vehicle's trajectories, the tracking error system is constructed with uncertainty. Secondly, according to the robust optimal control method, a performance index and an auxiliary system are designed, which convert the tracking driving problem into an optimal control problem. Besides, by iterating the Hamiltonian function and control policy, the control law is addressed, which is proved stabilizing the tracking driving dynamic. Finally, the simulation is implemented to verify the robust tracking control scheme, and the results demonstrate its effectiveness.

► FriC06-2 13:50–14:10

Dynamical Design of ADRC for One-DOF Manipulator Systems with Time-varying Disturbance and Large Parametric Uncertainty

Jiang, He Shaanxi Normal Univ.
Wu, Yinsuo Shaanxi Normal Univ.
Bai, Wenyan Acad. of Mathematics & Sys. Sci.,UCAS
Chen, Sen Shaanxi Normal Univ.
Zhao, Zhiliang Shaanxi Normal Univ.

In this paper, the control problem of one-degree-of-freedom robot manipulator systems with time-varying disturbance and significant parametric uncertainty is investigated. For the traditional linear active disturbance rejection control(ADRC), the choice of the nominal values of system parameters can signally influence the closed-loop stability. To achieve stronger robustness to the parametric uncertainties in manipulator systems, a new ADRC with dynamical design of control input is proposed. The proposed design contains an extended state observer to estimate total disturbance, and a dynamical system of control input to achieve the ideal input. Since the proposed ADRC only requires the signs of system parameters rather than the nominal values, a stronger capability of handling parametric uncertainties is shown. Finally, the comparative simulations of traditional ADRC and new design for manipulator system with three typical external disturbances and large parametric uncertainties are presented. When the closed-loop performance of the traditional ADRC becomes poor due to large parametric uncertainties, the proposed ADRC still results in a satisfied closed-loop performance.

► FriC06-3 14:10–14:30

A Novel ADRC Design with Cascade of Observers for Rigid-body Motion Control Systems

Chen, Zhixiang Qingzhou Hi-tech
Xue, Wenchao Chinese Acad. of Sci.
Mi, Wenpeng Qingzhou Hi-tech
Kong, Xiangtong Qingzhou Hi-tech
Bai, Wenyan Acad. of Mathematics & Sys. Sci.,UCAS

This paper considers the disturbance rejection problem for general rigid-body motion control systems. A novel active disturbance rejection control (ADRC) design with cascade of one high gain observer and one reduced-order extended state observer is proposed. It is shown that compared with the regular ADRC, the proposed ADRC method only needs the control direction, avoiding the difficulty of choosing the nominal control input gain. Moreover, such novel design has the same order as that of normal extended state observer. Moreover, the stability of the resulting closed-loop system is rigorously proven. Finally, simulation results of a 1 degree-of-freedom (DOF) manipulator control system demonstrate the

effectiveness of our method.

▶ FriC06-4 14:30–14:50

GA Optimized Fuzzy PID Control with Modified Smith Predictor for HVAC Terminal Fan System

Xie, Renyu	Zhejiang Univ.
Zhang, Tao	Zhejiang Univ.
Jiao, Xuguo	Qingdao Univ. of Tech.
Yang, Qinmin	Zhejiang Univ.

The terminal fan is an important part of the Heating Ventilation Air Conditioning (HVAC) system, which undertakes the task of transferring heat between the circulating fluid and the room air. Unfortunately, the large time-delay is inevitable because of the heat transfer process. Recent years have seen the successful applications of various artificial intelligent algorithms in solving optimization and control problems for complex systems. Therefore, it is of significant meaning to design a machine learning algorithms based intelligent control method to balance heat transfer efficiency, fan speed and energy consumption. In this paper, a second-order terminal fan system model with pure delay is constructed. Ensuingly, PID control is applied to control the fan' s speed, and fuzzy inference is used to adjust PID parameters. The fuzzy rules are optimized by genetic algorithm with the objective function designed according to performance indexes. The temperature difference control strategy guarantees heat transfer efficiency and energy saving of terminal fans. A modified Smith predictor is proposed to solve the time-delay mismatch problem further. The terminal fan system control process is simulated with different time delays, to confirm the robustness of the control algorithm.

▶ FriC06-5 14:50–15:10

Computer Simulation and Artificial Intelligence Driven Frameworks for Stability Analysis of Spacecraft Phase Plane Control Systems

Chen, Zhihua	Beijing Inst. of Control Engineering
Luo, Ruizhi	Beijing Inst. of Control Engineering
Liu, Wangkui	Harbin Inst. of Tech.
Guo, Jinhua	China Acad. of Launch Vehicle Tech.
Li, Yong	Beijing Inst. of Control Engineering
Guo, Yong	Northwestern Polytechnical Univ.
Zhang, Kai	Sichuan Univ.
Xie, Yongchun	Beijing Inst. of Control Engineering

For the stability analysis problem of spacecraft phase plane control systems, the author has proposed a computer simulation (CS)-based stability analysis framework in the previous work, which is called the CS driven framework in the following text. The overall idea of this framework is to obtain lots of data by CS firstly, and then propose a stability conjecture by analyzing the data with human, and finally draw a stability conclusion by proving the conjecture with human. Based on the CS driven framework, this paper proposes two CS and artificial intelligence (AI)-based stability analysis frameworks, which are called the CS and AI driven framework-I and framework-II in the following text. The framework-I finds the stability characteristics based on the CS data with AI firstly, and then proposes a corresponding stability conjecture by analyzing the CS data with AI, and finally draws a stability conclusion by proving the stability conjecture with human. Based on the CS and AI driven framework-I, the framework-II finally draws a stability conclusion by proving the stability conjecture with AI. Finally, two examples are provided to illustrate the potential feasibility of the proposed framework-I and the framework-II to analyze the stability of spacecraft phase plane control systems.

▶ FriC06-6 15:10–15:30

Model Free Adaptive Tracking Control of Multi-cascade Connection Systems with Switching Topology

Zhang, Zhipeng	Beiing Information Sci. & Tech. Univ.
Xiong, Shuangshuang	Beijing Information & Tech. Univ.
Hou, Zhongsheng	Beijing Jiaotong Univ.

A multi-cascade connection systems which consists of several subchains, and each subchain has a cascade connection between different subsystems is considered in this note. Multi-cascade connection systems can be converted as multiagent systems where each subchain is viewed as an agent and the connection between subchains can be seen as a topology structure between agents. This note focus on tracking control of multi-cascade connection systems with switching topology by using the model-free adaptive control (MFAC) method. A control algorithm is proposed to satisfy output tracking, in which only the input/output data of the neighbouring subchains and the desired signal are used. The convergence is proved by rigorous demonstration based on the algebraic theory and matrix theory. A numerical simulation is presented to illustrate the obtained results.

FriD01 15:40–17:40 Room 1

Invited Session: Data-Driven Adaptive Learning Control for Nonlinear Systems (II)

Organizer: Wang, Shubo	Qingdao Univ.
Organizer: Na, Jing	Kunming Univ. of Sci. & Tech.
Organizer: Chen, Qiang	Zhejiang Univ. of Tech.
Chair: Wang, Shubo	Qingdao Univ.
Co-Chair: Na, Jing	Kunming Univ. of Sci. & Tech.

▶ FriD01-1 15:40–16:00

USDE-Based Cascade Control for Servo Motor Systems with Uncertain Dynamics

Shi, Zhenghao	Kunming Univ. of Sci. & Technolog
Huang, Yingbo	Kunming Univ. of Sci. & Tech.
Na, Jing	Kunming Univ. of Sci. & Tech.

In this paper, a cascade control strategy is proposed for servo motor system with uncertaines and nonlinearities. With this method, not only the lumped unknown dynamics can be accommodated but also the armature current and position tracking performance can be guaranteed. To achieve this purpose, a set of filter operations and simple algebraic calculations are employed to design an unknown system dynamics estimator (USDE) with only one tuning parameter. Then, the USED is integrated with a typical PID controller and a feedback controller for current loop and position loop, respectively. The closed-loop system stability is analysed in terms of the Lyapunov theory. Finally, experiment is carried out based on autofocus optical system to validate the reliability and effectiveness of the proposed method.

▶ FriD01-2 16:00–16:20

Fast Configuration Identification and Matching Gains of RFA Based on Deep Learning Technology

Peng, Yong	Kunming Univ. of Sci. & Tech.
Yang, Chunxi	Kunming Univ. of Sci. & Tech.
Li, Yiming	Kunming Univ. of Sci. & Tech.
Na, Jing	Kunming Univ. of Sci. & Tech.

In order to expand the application scene of rotorcraft UAVs, a reconfigurable flight array has been proposed, which can be quickly assembled into different configurations to suit complex environments. However, the dynamics models of different configurations are inconsistent ,and different configurations correspond to different tracking controllers. The stability of a flying array during flight is the key topic, while stable flight depends on good control schedule corresponding to correct dynamic model. In this paper, we first give a general dynamical model of reconfigurable flight array, which shows that obtaining the coordinates of each unit module is the key to design stable control schedule. Then, a target detection algorithm is employed to identify the current configuration and the unit modules as to find the coordinates of each unit module. Finally, the tracking controllers of the two configurations are matched according to the configuration information of visual recognition, and the module coordinatesobtained by visual recognition and manual recognition are simulated and compared. The results show that the method proposed in this paper can identify the right configuration quickly and match suitable tracking controller for RFA to achieve fast and stable control.

▶ FriD01-3 16:20–16:40

Nonlinear Gain Extended State Observer Based Nonsmooth Funnel Control for Nonlinear Systems with Unknown Dynamics

Cheng, Yun	Beijing Inst. of Tech.
Ren, Xuemei	Beijing Inst. of Tech.

For the second order nonlinear systems with unknown disturbances, a nonsmooth funnel control (NSFC) method with a novel extended state observer (ESO) is designed to constrain the tracking error. The unknown total disturbance is extended to a new state, and then a nonlinear gain ESO (NLG-ESO) is developed to estimate it. The "peaking value problem" in the typical linear ESO (LESO) is addressed by the designed nonlinear gain, and the large observer gains in initial period is avoided. In addition, a funnel variable with the nonsmooth function is designed, and the NSFC can constrain the tracking error stay in a funnel zone with better tracking performance. Simulation results illustrate that the designed NSFC with NLG-ESO can achieve the control objectives.

▶ FriD01-4 16:40–17:00

Adaptive Command Filtered Control of Uncertain Nonlinear System with Friction Input

Sun, Guofa	Qingdao Univ. of Tech.
Zhang, Guoju	Qingdao Univ. of Tech.

Zhao, Erquan Qingdao Univ. of Tech.
Huang, Ming Yu Qingdao Univ. of Tech.

An adaptive command filter control of nonlinear system with friction input is formulated in this paper. First, based on the obtained state space model, a command filter control method is proposed, which can address the "explosion of complexity" problem existed in traditional backstepping design and ensure the asymptotic convergence of the tracking errors. Moreover, to cope with the problem of filter error between filter output and virtual control signal, dynamic error compensation system is designed. Next, a HONN system is employed to simplify the calculation and approximate the uncertainties in the system. At last, in order to clarify the effectiveness of the above theory, simulation results are given.

► FriD01-5 17:00–17:20

Identification of Cogging Force in Ironed Linear Motor Based on RBF Neural Networks Using Hybrid Self-Adaptive TLBO

Chen, Siwen Harbin Inst. of Tech.
Liu, Yang Harbin Inst. of Tech.
Song, Fazhi Harbin Inst. of Tech.

The cogging force is an intrinsic characteristic of linear motor, which is caused by the structure of linear motor. As a crucial disturbance, the cogging force seriously impairs the positioning accuracy of linear motor. The existing compensation approaches are hardly implemented or have a low accuracy in practice, due to the inaccurate model of the cogging force. In this paper, the identification problem of the cogging force of the linear motor is investigated. To compensate the unknown nonlinearity, the RBF neural network is utilized for fitting. Moreover, to overcome the local optimal solutions involved with the traditional TLBO method, a hybrid self-adaptive TLBO algorithm is adopted to train the neural network. Finally, experimental results confirm the effectiveness and advantage of the proposed method.

► FriD01-6 17:20–17:40

Hysteresis Feedforward Compensation of Reluctance Actuator: A Neural Network Approach Using Stochastic Configuration Network

Liu, Yang Harbin Inst. of Tech.
Miao, Qian Harbin Inst. of Tech.
Li, Li Harbin Inst. of Tech.

Since the current voice coil motor cannot break through the physical limit, the next-generation ultra-precision motion stage cannot meet the needs of high speed, high acceleration and high precision. To solve this problem, a new type of actuator must be developed and reluctance actuator has been proposed as one of the most potential candidates. However, the strong nonlinearity of the reluctance motor limits its application in ultra-precision. For example, the hysteresis effect, the relationship between force and current, and force and displacement, and so on. In this paper, a combined control strategy composed of feedforward compensation and PID is introduced to the reluctance actuator system, and the BP neural network and stochastic configuration network (SCN) are applied to the construction of the hysteresis inverse model. According to the simulation results, it can be concluded that the accuracy of the inverse model constructed by the SCN method is higher than that of the inverse model constructed by the BP neural network. It is concluded that the Stochastic Configuration Network method is effective for the hysteresis nonlinearity compensation of the reluctance actuators, and promising in precision stage control.

FriD02 15:40–17:40 Room 3

Regular Session: Statistical Learning and Machine Learning in Automation Field (II)

Chair: Li, Sheng Zhejiang Univ. of Tech.
Co-Chair: Zhang, Xiaoping North China Univ. of Tech.

► FriD02-1 15:40–16:00

The Graphical Analysis for Controllability of Multi-agent System Based on Equitable Partition

Su, Mengmeng Qingdao Univ.
Ji, Zhijian Qingdao Univ.

In this paper, we study the controllability of multi-agent systems by equitable partition and automorphism. For the case that cells are incompletely connected outside but completely connected inside, a necessary condition for controllability is given from the perspective of the rank of connection matrix. For the case of multiple cells being completely connected outside and incompletely connected inside, in terms of the eigenvalues and eigenvectors of L and $L_p i$, several sufficient and necessary conditions for controllability are presented. Once all nodes in nontrivial cells are leaders or the quotient graph is controllable under single input, the lower bound of controllable subspace is determined. Finally, we give the boundary between the necessary condition and the sufficient condition for controllability from the aspect of equitable partition.

► FriD02-2 16:00–16:20

BE-Net:Boudary-Enhanced Networks for Accurate Gland Segmentation

Fan, Zhenbang Zhejiang Univ. of Tech.
Dong, Sheng Zhejiang Univ. of Tech.
Shi, Shuling School of Information Engineering
Yang, Wenqin Zhejiang Univ. of Tech.
Li, Sheng Zhejiang Univ. of Tech.
He, Xiongxiong Zhejiang Univ. of Tech.

The morphology of glands is the gold standard for pathologists to assess the degree of benign and malignant adenocarcinoma in medical diagnosis. Accurate segmentation of glands is indispensable for a computer-aided diagnosis system. However, heterogeneity exists in glandular morphology between benign and malignant, and mutual adhesion of glands adds to the difficulties in determining glandular boundaries. This paper proposes a boundary-enhanced network (BE-Net) that repeatedly uses boundary information to segment glands accurately. The network adopts an encoder-decoder structure that uses the introduced global fusion module (GFM) as a decoder to advance aggregate features for explicit boundary refinement. In addition, we also propose a context-augmented attention module (CAAM) to refine implicit boundary and segment the gland boundary accurately through the repeated use of boundary information to improve the overall model's segmentation performance. The experiments demonstrate that the proposed method significantly outperformed other state-of-the-art methods on the Warwick-Qu dataset.

► FriD02-3 16:20–16:40

Spatial-Temporal Attention Transformer Model for Future Trajectory Forecast

Geng, Zhiqiang Beijing Univ. of Chemical Tech.
Zhang, Te Beijing Univ. of Chemical Tech.
Han, Yongming Beijing Univ. of Chemical Tech.

Human trajectory prediction is very important for people's safety. And human motion is essentially a multimodal motion, which brings great challenges to the trajectory prediction. Meanwhile, most sequence-to-sequence models only consider one of the temporal and spatial characteristics of pedestrian motion and ignore other. Therefore, based on the temporal and spatial attention mechanism and the transformer model, we fuse the temporal and spatial characteristics of the imputation, and propose a deep learning prediction model based on the spatial-temporal attention transformer mechanism (STATM). Our model designs a temporal attention module based on multi-head attention, a spatial attention module based on GAT, and finally maps spatial-temporal features to trajectory destinations through a transformer-decoder-like module. Compared with other methods, our model achieves better results on ETH and UCY public datasets.

► FriD02-4 16:40–17:00

Research on Real-time Road Crack Detection Algorithm Based on Improved Knowledge Distillation

Jiang, Yanyu North Minzu Univ.
Wei, Haicheng North Minzu Univ.
Wang, Suo Northern Univ. for Nationalities
Tian, Siyuan North Minzu Univ.

An intelligent real-time crack detection algorithm based on lightweight and knowledge distillation is proposed for existing crack detection systems that can hardly meet the road development needs. In this paper, YOLOv4 is used as the main framework, and MobileNetV3 is used as the backbone network, based on which the model is compressed and knowledge distilled. The experimental results show that the final model has 95.58% lower parameters than the YOLOv4 model, 66.22% higher inference speed, and 0.914 detection accuracy. The improved, streamlined model has high precision, good detection effect, and fast operation speed, and is suitable for deployment on miniaturized embedded systems with in-vehicle as the platform.

► FriD02-5 17:00–17:20

Architecture Growth of Dynamic Feedforward Neural Network Based on the Growth Rate Function

Zhang, Xiaoping North China Univ. of Tech.
Yang, Tianhang North China Univ. of Tech.
Wang, Li North China Univ. of Tech.
Liu, Shida Beijing Jiaotong Univ.
Yan, Jiaqing North China Univ. of Tech.

He, Zhonghe North China Univ. of Tech.

At present, when artificial neural network is widely used to deal with practical problems, there is no theoretical choice on network scale guidance. Users often use empirical or trial-and-error methods to find an appropriate scale of the network. When the scale is too large, the neural network will need to calculate a large number of parameters when carrying out forward and back propagation, it will cause a waste of resources and time, and will also cause overfitting.If the scale is too small, it will cause underfitting. To solve this problem, a simple, effective and easy method that to realize network growth is proposed in this paper. Taking the multi classification problem as an example,the two most important indexes that can best reflect the performance of neural network are loss of error and recognition rate. Based on this, a growth function is designed to adjust the network continuously according to the output loss of error and recognition rate before and after the network growth. The experimental results show that the network grows to a scale that can reach the peak of network recognition rate.

▶ FriD02-6 17:20–17:40

Spatio-Temporal View GAIN for Data Imputation and Dynamic Soft Sensor

Ren, Jiayi Zhejiang Univ.
Chen, Xu Zhejiang Univ.
Zhao, Chunhui Zhejiang Univ.

Soft sensor plays a key role in the safe operation of industrial processes and product quality control. Affected by closed-loop feedback, process data often demonstrate certain dynamic characteristics. In addition, traditional soft sensor methods are often based on the assumption of completeness. Once part of the data is missing, the above methods will collapse. In this paper, we propose a Spatio-Temporal view Generative Adversarial Imputation Network (GAIN) for data imputation and apply dynamic soft sensor for block missing accompanied with completely random missing data. Initially, a data pre-imputed strategy is designed to first impute the missing data through GAIN from the perspective of data distribution. Secondly, on the basis of pre-imputation, a data imputation strategy that integrates time and space information is proposed to impute the data precisely, which can comprehensively consider the time series of process data and the correlation between variables, and further improve the accuracy of data imputation. Finally, we propose a dynamic soft sensor method to make real-time predictions of the data. The effectiveness of the proposed method is verified by the Tennessee Eastman (TE) process.

FriD03 15:40–17:40 Room 4

Invited Session: New Trends on Data-driven Control, Learning and Detection for Complex Systems

Organizer: Li, Jinna Liaoning Shihua Univ.
Organizer: Lang, Xianming Liaoning Petrochemical Univ.
Chair: Li, Jinna Liaoning Shihua Univ.
Co-Chair: Lang, Xianming Liaoning Petrochemical Univ.

▶ FriD03-1 15:40–16:00

Stabilizing Control of Markovian Jump Systems with Switching and State Signal Data Sampling under Denial-of-Service

Wang, Guoliang Liaoning Shihua Univ.
Ren, Yunshuai Liaoning Petrochemical Univ.

The stabilization problem of continuous-time Markovian jump systems (MJSs) under Denial-of-Service (DoS) is studied. An auxiliary system with an exponential matrix is proposed to solve the problem that both switching and state signals data are sampled. By coordinating the sampling rate, the frequency and duration of DoS attack, the sufficient stabilization conditions are presented. A numerical example is offered to demonstrate the utility of the proposed methods.

▶ FriD03-2 16:00–16:20

Rolling Bearing Fault Diagnosis Based on Mixed Data Feature Undirected Graph

Wang, Guoliang Liaoning Shihua Univ.
Ren, Xueyu Liaoning Petrochemical Univ.

Based on the selection and investigation of appropriate signal dynamic analysis indexes, by analyzing the mixed time-domain characteristics of vibration signals, combined with graph theory algorithm, the correlation between data features is analyzed, the correlation characteristics of analyzed data features are used as feature vectors, and support vector machine is used as classifier to identify bearing fault types, so as to achieve the purpose of bearing fault diagnosis, The undirected graph adjacency matrix constructed by this method can realize the overall expression of each eigenvalue data from a global perspective. Compared with the conventional diagnosis method based on data analysis, it further improves the accuracy of fault diagnosis.

▶ FriD03-3 16:20–16:40

Consensus of Nonlinear Multi-agent Systems with Uncertainties Using Reinforcement Learning Based Sliding Mode Control

Yuan, Lin Liaoning Petrochemical Univ.
Li, Jinna Liaoning Shihua Univ.

This paper investigates distributed control protocols designed for uncertain nonlinear multi-agent systems with the goal of achieving the optimal consensus. The critical challenges encountered when designing the optimal distributed control protocols are mainly caused by the internal coupling of agents, uncertainty and nonlinear dynamics. Communication delay among agents makes overcoming these challenges even more difficult. To this end, a novel sliding mode control design method is developed based on sliding mode control principle and reinforcement learning technique. The remarkable highlights of the developed method in this paper include the designs of distributed sliding mode surface and reinforcement learning algorithm with the outcome of successfully learning the composite distributed control protocols, such that all agents can completely eliminate the negative impacts brought by system uncertainties and communication delay among agents, and finally follow the leader with a nearly optimal approach. The reachability of sliding mode surface and optimal consensus are rigorously proved and analyzed. Finally, simulation results illustrate the effectiveness of the developed method.

▶ FriD03-4 16:40–17:00

Sliding Mode Control Based Consensus of Discrete-time Nonlinear Multi-agent Systems

Yuan, Lin Liaoning Petrochemical Univ.
Li, Jinna Liaoning Shihua Univ.

This article investigates the optimal sliding mode control approach for consensus of nonlinear discrete-time high-order multi-agent systems (MASs). First, the nonlinearity and communication delay in the MAS is solved by designing a distributed discrete-time integral sliding mode control law, together with a proof of reachability of the sliding mode surface, as well as a proof that the chatter of the system is attenuated. In addition, the optimal controller is designed based on the model obtained after the distributed sliding mode control law is applied to the system. The merits of the proposed distributed sliding mode controller with the fusion of optimal control are that it can reduce the chatter of the MASs and their existence of quasi-sliding modes, as well as tolerate the negative impact caused by communication delay among agents. The MASs can achieve consensus quickly with the combined action of the sliding mode controller and the optimal controller. Finally, two examples are given to verify the effectiveness of the control method proposed in this paper.

▶ FriD03-5 17:00–17:20

Pipeline Leak Detection Method Based on DTWSVM

Lang, Xianming Liaoning Petrochemical Univ.
Zhu, Yongqiang Liaoning Petrochemical Univ.
Cai, Zefeng North China Air Traffic Management Bureau CAAC

In order to accurately identify pipeline leaks, this paper proposes a Uniform Phase Empirical Mode (UPEMD) denoising method based on mutual information optimization and a pipeline leak detection method based on Deep Twin Support Vector Machine (DTWSVM). The signal is first decomposed into multiple intrinsic modal functions (IMF) by UPEMD, and then the IMFs containing more leakage information are selected for reconstruction by mutual information value. The obtained signal contains less noise and clear inflection points. DTWSVM is a three-layer network model that combines deep learning (DL) and Twin Support Vector Machine (TWSVM.) The three TWSVMs in the hidden layer can extract the features of the signal, and the main TWSVM in the output layer judges the pipeline conditions according to the extracted features. The experimental results show that the recognition accuracy of DTWSVM can reach up to 99.7%.

▶ FriD03-6 17:20–17:40

Magnetic Flux Leakage Image Recognition Method of Pipeline Defects Based on Low-level Feature Fusion Multi-core Convolution Neural Network

Lang, Xianming Liaoning Petrochemical Univ.
Han, Fucheng Liaoning Petrochemical Univ.
Cai, Zefeng North China Air Traffic Management Bureau CAAC

In order to improve the accuracy of magnetic flux leakage image recog-

nition of pipeline defects, a method based on low-level feature fusion multi-core convolution neural network is proposed. Firstly, a Concatenation module composed of multiple convolution kernel concat operations is constructed. The recognition model is composed of three Concatenation modules and full connection layer. The model can obtain i nformation of different scales. Then, the original image is down sampled and fused with the feature map obtained after the convolution operation of the first Concatenation module. The model can get more space, color, outline and other information.Then feature extraction is carried out through two-layer Concatenation module,the last step is classification prediction.The experimental results show that the accuracy of the model with low-level features is 2.4% higher than that without low-level features, and 11.5% higher than that of CNN.

FriD04 15:40–17:40 Room 5

Invited Session: Physics/Knowledge-Informed Learning in Process Data Analytics

Organizer: Liu, Yi — Zhejiang Univ. of Tech.
Organizer: Yao, Yuan — National Tsing Hua Univ.
Organizer: Yang, Tao — Northeastern Univ.
Chair: Liu, Yi — Zhejiang Univ. of Tech.
Co-Chair: Yang, Tao — Northeastern Univ.

► FriD04-1 15:40–16:00

Particle Filter Based Robust State and Parameter Estimation for Estimating SOC and Discharge Current of Lithium Batteries

He, Yijia — Wenzhou Univ.
Hong, Zhihui — Wenzhou Univ.
Zhang, Zhengjiang — Wenzhou Univ.
Huang, Shipei — Nanjing Univ. of Sci. & Tech.

The State of Charge (SOC) of lithium batteries can be estimated effectively by particle Filter (PF). However, it is difficult to accurately obtain the value of the parameter discharge current of the lithium battery in the actual process, which affects the accuracy of the PF for SOC estimation. In order to solve the problem, this paper proposes a particle filter based robust state and parameter estimation (PF-RSPE) method for estimating SOC and discharge current of lithium batteries. The method estimates SOC and the unknown parameter discharge current simultaneously. The unknown parameter is expanded to the states of the model. The kernel smoothing method with the fitness factor is applied in the procedures of the simultaneous estimation, which improves the performance of the estimation. Finally, the proposed method is applied to the equivalent model of Thevenin battery for simulation verification. The results show that when the parameter discharge current is unknown, the PF-RSPE method can effectively estimate both SOC and discharge current.

► FriD04-2 16:00–16:20

Pseudo-label Estimation Based on EDA for Semi-supervised Soft Sensor Development

Rao, Feihong — Kunming Univ. of Sci. & Tech.
Jin, Huaiping — Kunming Univ. of Sci. & Tech.
Liu, Haipeng — Kunming Univ. of Sci. & Tech.
Yang, Biao — Kunming Univ. of Sciecnce & T

Data-driven soft sensing is widely used in the process industry to realize online prediction of difficult-to-measure variables. However, the lack of labeled data and the abundance of unlabeled data in the process industry restrict the development of semi-supervised soft sensing. Assigning high-quality pseudo-labels to expand labeled data is an effective method for improving the semi-supervised model. In this respect, this paper proposes a method based on the estimation of distribution algorithm (EDA), known as EDA-based pseudo label estimation (EDPLE), which combines traditional pseudo-label generation and confidence evaluation into an optimal estimation problem of label probability distribution. The error accumulation in traditional iterative learning is alleviated considerably via this method, and high-quality of pseudo-labels are ensured. the quality of pseudo-labels. In the EDPLE method, the optimization objective consists of prediction accuracy, prediction uncertainty and manifold learning, and a multivariable probability model is designed. Subsequently, the EDA is used to solve the optimization problem to obtain high-confidence pseudo-labels. Therefore, a semi-supervised soft-sensing model based on labeled and pseudo-labeled data is established in this study. In real industrial cases, the proposed method outperform the existing pseudo-label-based semi-supervised soft-sensing method.

► FriD04-3 16:20–16:40

Adaptive Ensemble Model for Ultra-short-term Wind Power Forecasting

Li, Yunlong — Faculty of Information Engineering & Automation, Kunming Univ. of Sci. & Tech.
Jin, Huaiping — Kunming Univ. of Sci. & Tech.
Liu, Haipeng — Kunming Univ. of Sci. & Tech.
Jin, Huaikang — Huaneng Renewables Co.,Ltd.Yunnan Branch
Cao, Yundong — Huaneng Renewables Co., Ltd. Yunnan Branch

Stable and reliable wind power forecasting is of great significance for grid dispatching. However, wind power has strong nonlinear characteristics. Its amount of historical data is very large, and traditional machine learning methods cannot fit the nonlinear relationship well. Furthermore, owing to the seasonality and periodicity of the wind power, the performance of the offline model inevitably deteriorates. To address these problems, this study proposes an adaptive ensemble model for ultra-short-term wind power forecasting. First, a long short-term memory (LSTM) network is established with historical wind power data for an entire year to ensure a strong generalization performance. Second, local weighted partial least squares (LWPLS) were used to obtain LSTM network prediction errors in real time by adaptive modeling and further improving its prediction accuracy. In addition, just-in-time learning (JITL) is used to ensure the adaptability of forecasting using LWPLS. Finally, to fully integrate the prediction advantages of different prediction models, a random forest (RF) was used to transform the determination of the ensemble weight into a three-classification problem. The adaptive fusion of the three different forecasting mechanisms is realized by weighting through the posterior probability of classification. Finally, the effectiveness and superiority of the proposed method are verified in a practical case.

► FriD04-4 16:40–17:00

Topology-Informed Graph Convolutional Network for Fault Diagnosis

Jia, Mingwei — Zhejiang Univ. of Tech.
Xu, Danya — Northeastern Univ.
Yang, Tao — Northeastern Univ.
Yao, Yuan — National Tsing Hua Univ.
Liu, Yi — Zhejiang Univ. of Tech.

The development of an accurate data-driven fault diagnosis model faces several obstacles. One significant challenge is how to combine the model with the process mechanism rationally and improve the model interpretability. In this work, a fault diagnosis method based on a topology-informed graph convolutional network (TIGCN) is proposed. This model first uses the empirical knowledge that analyzes the operating state of the process and combines the operating data to construct a signed directed graph. Then the operating data is divided into three modalities in the time dimension. The model utilizes a well-designed spatial-temporal convolutional layer and signed directed graph to construct different modalities separately to effectively detect fault types. The superior fault diagnosis performance of the proposed TIGCN model is demonstrated on the Tennessee-Eastman process as compared to traditional approaches.

► FriD04-5 17:00–17:20

Fault Root Diagnosis of Industrial Process Based on Random Forest-Partial Symbol Transfer Entropy

Zhu, Yu-Rong — Shanghai Univ.
Wang, Jian-Guo — Shanghai Key Lab of Power Station Automation Tech., Shanghai Univ.
Su, Jing Ru — Shanghai Univ.
Yao, Yuan — National Tsing Hua Univ.
Zhang, Liu-Wei — Shanghai Univ.
Chen, He-Lin — Baoshan Iron & Steel Co. Ltd

Fault diagnosis is an important means to protect the safety of industrial processes. In recent years, the causal analysis method based on data driven is widely used in industrial process of the fault root diagnosis, such as the transfer entropy(TE), which is able to quantify information transfer between two time series and get a direct causal relationship between two variables. Partial transfer entropy (PTE) is a multi-dimensional extension of TE, only recognize the direct causal relationship. But PTE method is not suitable for the non-stationary process, and the computational complexity is very high, so this paper proposes a Random forest-Partial symbols transfer entropy method (RF-PSTE) to identify the network of causal relationship. It is not only suitable for non-stationary systems but also can reduce the computational complexity by reducing the number of confounding variables. Finally through the Tennessee Eastman process(TEP) chemical process as an example to verify the effectiveness of the proposed method.

► FriD04-6 17:20–17:40

Multi-time Scale Granger Causality Analysis for Disturbance Diagnosis

Yu, Guo-Yuan — Shanghai Univ.

Wang, Jian-Guo — Shanghai Key Lab of Power Station Automation Tech., Shanghai Univ.
Ye, Xiangyun — Shanghai Univ.
Yao, Yuan — National Tsing Hua Univ.
Zhang, Liu-Wei — Shanghai Univ.
Chen, He-Lin — Baoshan Iron & Steel Co. Ltd

Granger causality, as a simple and effective data-driven system time series analysis tool, has been applied in many fields. It is easy to implement, easy to learn, and fast to calculate. In recent years, Granger causality analysis is often used in the data analysis of industrial process data, and many researchers have proposed optimization frameworks. However, these methods often ignore the existence of multi-time-scale dynamics in the field of industrial process data analysis. This paper proposes to apply the multi-time scale Granger with data scaling by ISS to the diagnosis of the root cause of disturbances in multivariable complex industrial processes. Through the practical application of disturbance 7 of the TE process, it is proved that this method can accurately find the root cause can be derived, It proves that the multi-time scale Granger causality analysis framework based on ISS is effective and valuable in the root cause diagnosis of industrial process data.

FriD05 15:40–17:40 Room 6
Invited Session: Data-Driven Security Control for Networked Control Systems

Organizer: Che, Wei-Wei — Qingdao Univ.
Organizer: Ma, Yongsheng — Qingdao Univ.
Chair: Che, Wei-Wei — Qingdao Univ.
Co-Chair: Ma, Yongsheng — Qingdao Univ.

▶ FriD05-1 15:40–16:00
Adaptive Fuzzy Asymptotic Tracking Control for Fractional-Order Nonlinear Systems with Nonstrict-Feedback Structure

Li, Xiao — Qingdao Univ.
Li, Yuan Xin — Liaoning Univ. of Tech.
Che, Wei-Wei — Qingdao Univ.

This paper solves the adaptive dynamic surface asymptotic tracking control problem of fractional order nonlinear systems(FONSs) with non-strict feedback structure. Firstly, the fuzzy logic systems(FLSs) is utilized to deal with unknown nonlinear functions to eliminate the influence of uncertainty. Secondly, the problem of "complexity explosion" is solved by designing dynamic surface control(DSC) algorithm. The stability and asymptotic tracking performance of the system are proved by using fractional Lyapunov function theory. Finally, a simulation example is supplied to verify the effectiveness of the control method.

▶ FriD05-2 16:00–16:20
Event-triggered Adaptive Neural Network Asymptotic Control for Nontriangular Stochastic Nonlinear Systems

Liu, Yongchao — Harbin Engineering Univ.
Zeng, Bowen — Harbin Engineering Univ.

This paper designs an event-triggered adaptive neural network asymptotic control (ANNAC) method for nontriangular stochastic nonlinear systems (SNS). In contrast to published neural network schemes where the tracking errors converge bounded regions, a bound estimation scheme is given for every subsystem based on backstepping technique. The presented event-triggered ANNAC method can make the considering closedloop systems to be asymptotically stable.

▶ FriD05-3 16:20–16:40
Proportional-integral Interval Observer for Linear Continuous-time Systems

Zhang, Tu — Nanjing Tech Univ.
Wu, Xingzheng — Nanjing Tech Univ.
Li, Liwei — Northeastern Univ.
Shen, Mouquan — Nanjing Tech Univ.

This work investigates H_{infty} proportional-integral interval observer for linear continuous-time systems via bounded disturbances. To reestablish system states with more dynamic information, three estimation approaches are provided by means of system outputs, namely, Luenberger type is given firstly without any prior constraints. Resorting to the framework of former, cooperativity is ensured by coordinate transformation in second approach. Lastly, extra parameters supplied by unknown input observer structure is utilized to contain all possible trajectories with less conservatism than second one. A structure separation technique is employed to overcome the nonlinearity induced by the third method. Sufficient conditions are provided in terms of linear matrix inequalities to satisfy prescribed H_{infty} requirement. Simulations studies confirm its validity.

▶ FriD05-4 16:40–17:00
Tracking Control for Constrained Nonlinear Systems

Zhu, Lin — Qingdao Univ.
Yue, Bai-Fan — Qingdao Univ.
Che, Wei-Wei — Qingdao Univ.

A new input-output constrained (IOC) model-free adaptive tracking control (IOC-MFATC) problem for nonlinear constrained systems against DoS attacks is studied in this paper. Firstly, considering malicious attacks in the network, an attack compensation mechanism is introduced to compensate for DoS attacks. And due to the restriction of practical physical conditions, the IOC strategy is put forward to guarantee the equipment security. Then, for the nonlinear system with unknown model, the new IOC-MFATC algorithm designed with the input and output data can guarantee the safe tracking control problem. Finally, the simulation results demonstrate the effectiveness of the presented algorithm.

▶ FriD05-5 17:00–17:20
Event-Triggered Optimal Containment Control for Multi-Agent Systems with State Constraints by Reinforcement Learning

Wang, Lijie — Qingdao Univ.
Xu, Jiahong — Bohai Univ.
Liu, Yang — Guangdong Univ. of Tech.

The paper studies the problem of optimal containment control for multi-agent systems (MASs) with communication constraints. The developed optimal control scheme is capable of guaranteeing systems performance from two aspects: 1) the state of each follower is remained within the constrained set; 2) the controller is updated based on the designed event-triggered condition, which greatly improves the utilization rate of resources. First of all, the problem of state constraints for multi-agent systems is transformed into an equivalent unconstrained case by designing proper barrier functions. Secondly, a novel event-triggered mechanism is constructed for designing the optimal controller, which can reduce the computational and communication costs compared with the time-triggered control scheme. To solve the event-triggered Hamilton-Jacobi-Isaacs equation (HJIE), a simplified reinforcement learning algorithm based on the actor-critic network is proposed. This proposed algorithm can remove the requirement of persistent excitation conditions. In general, an event-triggered optimal control scheme is developed to ensure that all followers eventually converge to the convex hull formed by leaders. Meanwhile, the state of each follower does not violate the desired sets. Finally, the effectiveness of the proposed scheme is verified by a simulation example.

▶ FriD05-6 17:20–17:40
Model-Free Adaptive Sliding Mode Control for Discrete-Time Nonlinear Systems with Sensor Fault and Prescribed Performance

Hao, Li-Ying — Dalian Maritime Univ.
Yang, Sen — Dalian Marine Time Univ.
Liu, Dong — Shenyang Aerospace Univ.

This paper concentrates on the issue of a model-free adaptive sliding mode control approach for a family of discrete-time single-input and single-output (SISO) nonlinear systems with sensor fault and prescribed performance. First of all, we set out to build an approximator that is based on radial basis function neural network to estimate the sensor fault offline, and for the purpose of restricting the tracking error in a prescribed region when the sensor fault occurs, the prescribed performance control (PPC) method is adopted. Then, we consider sliding mode control strategy to achieve the stability and ensure the convergence of tracking error within PPC scheme. We have to point out that all of these works above are carried in model-free adaptive control (MFAC) framework. Finally, a simulation example result is given to validate the effectiveness of the algorithm proposed in this article.

FriD06 15:40–17:40 Room 7
Regular Session: Data-driven Technique and Its Industrial Application

Chair: Chen, Yong — Univ. of Electronic Sci. & Tech. of China
Co-Chair: Li, Yan — Shandong Univ.

▶ FriD06-1 15:40–16:00
Energy Balance Based Attack Detection for Cyber Physical Systems

Li, Zhuyuan — Peking Univ.
Yang, Ying — Peking Univ.
Zhao, Zhengen — Nanjing Univ. of Aeronautics & Astronautics
Liu, Ruijie — Univ. of Shanghai for Sci. & Tech.

In this brief, the deficiency of a widely-used observer-based attack detection scheme for cyber physical systems (CPS) is analyzed and then

a novel energy balance based attack detector is proposed. Firstly, the definition of kernel attacks is introduced to capture the stealthy attacks which can not be detected through well-established observer-based techniques. Further, a data- driven design of kernel attacks based on subspace identification methods deploying input and output data is presented. To detect kernel attacks, a dissipativity-based attack detector is formulated in light of energy balance equation, providing a complementary strategy to guarantee reliable detection of attacks. Finally, the validity of the presented approach is demonstrated in a numerical example.

► FriD06-2 16:00–16:20

Data-driven Unscented Kalman Filter for State of Charge Estimation of Li-ion Batteries

Xu, Huiqin	Shandong Univ.
Li, Yan	Shandong Univ.
Yu, Meijuan	Shandong Univ.

With the widespread use of lithium-ion batteries (LIBs), prolonging the lifespan of LIBs is taken into account due to the polluting process of manufacturing and disposal compared to the clean using process of LIBs, which makes precise state of charge (SOC) estimation an essential for battery management systems (BMS). In this paper, a data-driven method (random forest, RF) based unscented Kalman filter (UKF) SOC estimation approach is proposed which considers different temperatures and can realize online implementation. Firstly, the RF is used to model the LIBs on the basis of voltage, current, voltage increment, and temperature. Then, UKF is employed to reduce the variances. Finally, the proposed method is validated by two dynamic profiles, Federal Driving Schedule and US06 Highway Driving Schedule, which indicates the RF-UKF approach is efficient in SOC estimation with the max errors within 0.72% and RMS errors within 0.4%.

► FriD06-3 16:20–16:40

Event-Triggered Sliding-Mode Cruise Control for Multibody High-Speed Train

Yu, Wei	Southwest Jiaotong Univ.
Huang, Deqing	Southwest Jiaotong Univ.
Cai, Liangcheng	Southwest JiaoTong Univ.
Wu, Yue	Southwest Jiaotong Univ.

The sliding-mode cruise control for multibody high-speed train (HST) is studied with an event-triggered communication scheme in the paper. Firstly, the error equation model of the HST with multibody is established with the consideration of time-varying running resistance. Then, the sliding-mode controller (SMC) is designed, and the event-triggered mechanism is constructed to reduce the transmission frequency. Next, by employing the Lyapunov stability theory, the convergence of the error equation of HST is analyzed and the proposed methods are verified by a Japan Shinkansen example.

► FriD06-4 16:40–17:00

Adaptive Optimal Control of Completely Unknown Systems with Relaxed PE Condition

Luo, Rui	Univ. of Electronic Sci. & Tech. of China
Peng, Zhinan	Univ. of Electronic Sci. & Tech. of China
Hu, Jiangping	Univ. of Electronic Sci. & Tech. of China
Ghosh, Bijoy	Texas Tech Univ.

This paper proposes a novel identifier-critic (IC) learning control strategy for completely unknown nonlinear system. Different from the existing results, the proposed IC control is capable of obtaining the optimal control under relaxed persistence of excitation (PE). A neural network (NN) based identifier is established to approximate the unknown system dynamics. After that, an only-critic NN framework is proposed to solve the Hamiltonian-Jacobi-Bellman (HJB) equation such that the control policy is obtained. To estimate the unknown weights of both identifier NN and critic NN simultaneously without strictly PE limitation, the dynamic regressor extension and mixing (DREM) technique is introduced to design the NN weight update laws. Meanwhile, new easy-to-check online convergence conditions for the proposed adaptive laws are given to ensure the unknown weights converge to their ideal values. In addition, theoretical analysis is also given to prove the significant relaxation of the proposed convergence conditions compared with the standard PE assumption.

► FriD06-5 17:00–17:20

Detecting Incipient Fault Using Wasserstein Distance

Lu, Cheng	China Jiliang Univ.
Zeng, Jiusun	China Jiliang Univerisity
Luo, Shihua	Jiangxi Univ. of Finance & Economics
Kruger, Uwe	Rensselaer Polytechnic Inst.

This article develops a novel process monitoring based on the Wasserstein distance for incipient fault detection. The core idea is to measure the difference between the normal data and the faulty data. For Gaussian distributed process variables, the paper proved that the difference measured by the Wasserstein distance is more sensitive than the Hotellings T2 and the Squared Prediction Error (SPE) in the Principal Component Analysis (PCA) framework. For non-Gaussian distributed data, a Project Robust Wasserstein distance (PRW) model under the PCA framework is proposed and an algorithm called Riemannian Block Coordinate Descent (RBCD) algorithm is used to solve this model, which is fast when the number of sampled data is large. An application study to a glass melter demonstrate the effectiveness of the proposed method.

► FriD06-6 17:20–17:40

Attention-based Stacked Supervised Poisson Autoencoders for Defects Prediction in Casting-rolling Process

Zhang, Xinmin	Zhejiang Univ.
Song, Zhihuan	Zhejiang Univ.
Ge, Zhiqiang	Zhejiang Univ.

In this paper, we propose an attention-based stacked supervised Poisson autoencoders (ASSPAE) modeling framework to predict the occurrence of defects in the casting-rolling process. ASSPAE is a novel deep learning model, which is designed based on the stacked supervised Poisson autoencoders and attention-based multi-feature fusion strategy. Stacked supervised Poisson autoencoders are a novel deep neural networks model, which is designed by integrating the Poisson regression network layer into the deep autoencoders framework. Compared with the conventional autoencoder-based models, stacked supervised Poisson autoencoders not only can capture the quality-relevant deep features of the data, but also is suitable for predicting the count-type quality variable. Furthermore, in order to efficiently leverage information present in different layers of the network, an attention-based multi-feature fusion strategy is integrated into the stacked supervised Poisson autoencoders modeling framework. The effectiveness of the proposed ASSPAE method is evaluated by its application to the cast-rolling process of a steelmaking plant. The application results show that the proposed ASSPAE modeling method outperforms several state-of-the-art methods.

Author Index

(O=Organizer, C=Chair, CC=Co-Chair)

M

Chair/Co-Chair Index

(C=Chair, CC=Co-Chair)

Wednesday, Aug. 3, 2022, Le Meridien Emei Mountain Resort (峨眉山恒邦艾美度假酒店)			
Time/Room	Lobby	Time/Room	Emei Ballroom 1(峨眉厅 1)
14:00-20:00	Register	14:30-17:00	Pre-Conference Workshop：Intelligent Railway Transportation System：Progress and Applications

Thursday, Aug. 4, 2022, Le Meridien Emei Mountain Resort (峨眉山恒邦艾美度假酒店)
8:00-8:30 Opening ceremony, Venue: Grand Ballroom (大宴会厅), Chair: Prof. Jing Wang
8:30-9:30 Keynote Address 1: Self-learning Optimal Control for Power Systems by Using ADP: Recent Results and Applications, Prof. *Huaguang Zhang*, Chair: Prof. Chenghong Wang
9:30-10:00 Tea Break and Photo
10:00-11:00 Keynote Address 2: Dynamic Latent Feature Learning and Troubleshooting of Manufacturing Processes, Prof. *S. Joe Qin*, Chair: Prof. Mingxuan Sun
11:00-12:00 Keynote Address 3: 高速铁路牵引供电系统故障预测与健康管理, Prof. *高仕斌*, Chair: Prof. Dongbin Zhao
12:00-13:00 Lunch

Time/Room	Grand Ballroom1 (大宴会厅 1)	Time/Room	Room 1	Room 3	Room 4	Room 5	Room 6	Room 7
13:10-15:30	Distinguished Lecture	13:30-15:30	ThurA01	ThurA02	ThurA03	ThurA04	ThurA05	ThurA06
13:10-13:45	Distinguished Lecture 1: De novo Design of Gene Regulatory Cdes using AI, Prof. *Xiaowo Wang*, Chair: Prof. Xiongxiong He	13:30-15:30	Iterative Learning Control (I)	IS: Control and Learning in Human-Robot Interaction Systems	Data-Driven Fault Diagnosis and Health Maintenance (I)	Statistical Learning and Machine Learning in Automation Field (I)	Model-free Adaptive Control	Best Paper
13:45-14:20	Distinguished Lecture 2: Networked Collective Intelligence in Intelligent Transportation System, Prof. *Wenwu Yu*, Chair: Prof. Youqing Wang							
14:20-14:55	Distinguished Lecture 3: Perception and Decision-Making in Autonomous Intelligent Systems, Prof. *Yang Tang*, Chair: Prof. Deqing Huang							
14:55-15:30	Distinguished Lecture 4: Intelligent Identifying and Self-healing Control for Municipal Wastewater Treatment , Prof. *Honggui Han*, Chair: Prof. Xuhui Bu							
15:30-15:40	Tea Break							

Time/Room	Grand Ballroom1 (大宴会厅 1)	Time/Room	Room 1	Room 3	Room 4	Room 5	Room 6
15:40-18:00	Distinguished Lecture	15:40-17:40	ThurB01	ThurB02	ThurB03	ThurB04	ThurB05
15:40-16:15	Distinguished Lecture 5: Data-Driven Robust Modeling and Learning Modeling of Ironmaking Blast Furnace, Prof. *Ping Zhou*, Chair: Prof. Jing Na	15:40-17:40	Data Driven Control (I)	Data-Driven Control for Practical Complex Processes	IS: ADRC: Design, Theory and Application	IS: Explainable Fault Diagnosis and Performance Optimization	Data-Driven Modeling, Optimization and Scheduling (I)
16:15-16:50	Distinguished Lecture 6: Smart Data-Driven Soft Sensor Model for Quality Prediction of Multigrade Processes, Prof. *Yi Liu*, Chair: Prof. Zhuo Wang						
16:50-17:25	Distinguished Lecture 7: Data-Driven Iterative Learning Control, Prof. *Ronghu Chi*, Chair: Prof. Wenchao Xue						
17:25-18:00	Distinguished Lecture 8: Data-Driven Security Control against Network Attacks , Prof. *Weiwei Che*, Chair: Prof. Hongyi Li						
18:00-20:00	Dinner						

Friday, Aug. 5, 2022, Le Meridien Emei Mountain Resort (峨眉山恒邦艾美度假酒店)							
Time/Room	Room 1	Room 3	Room 4	Room 5	Room 6	Room7	Emei Ballroom
8:00-12:10	FriA01	FriA02	FriA03	FriA04	FriA05	FriA06	FriA07
8:00--10:00	Iterative Learning Control (II)	IS: Repetitive Control and its Recent Advance	Data-Driven Modeling, Optimization and Scheduling(II)	Applications of Data-Driven Methods to Industrial Processes	IS: Advanced Control for Fuzzy and Time Delay Nonlinear Systems	ILC and Adaptive Control	Poster session (I)
10:00-10:10	Tea Break						
Time/Room	Room 1	Room 3	Room 4	Room 5	Room 6	Room7	Emei Ballroom
10:10-12:10	FriB01	FriB02	FriB03	FriB04	FriB05	FriB06	FriB07
10:10-12:10	IS: Data based Learning and Control	IS: Intelligent Control for Complex Nonlinear Systems	Data driven control (II)	Neural networks, fuzzy systems control in data driven manner (I)	Data-Driven fault diagnosis and health maintenance (II)	Neural networks, fuzzy systems control in data driven manner (II)	Poster session (II)
12:10-13:30	Lunch						

Time/Room	Room 1	Room 3	Room 4	Room 5	Room 6	Room7
13:30-15:30	FriC01	FriC02	FriC03	FriC04	FriC05	FriC06
13:30-15:30	IS: Data-Driven Adaptive Learning Control for Nonlinear Systems (I)	Deep Neural Network and Reinforcement Learning Control	IS: Data-Driven Modeling and Adaptive ILC	IS: RNN for Signal Processing and its Applications	IS: Data-Driven Virtual-sensor: Algorithm, Architectures and Applications	ADRC and Robust Control
15:30-15:40	Tea Break					
Time/Room	Room 1	Room 3	Room 4	Room 5	Room 6	Room7
15:40-17:40	FriD01	FriD02	FriD03	FriD04	FriD05	FriD06
15:40-17:40	IS: Data-Driven Adaptive Learning Control for Nonlinear Systems (II)	Statistical Learning and Machine Learning in Automation Field (II)	IS: New Trends on Data-Driven Control, Learning and Detection for Complex Systems	IS: Physics/Knowledge-Informed Learning in Process Data Analytics	IS: Data-Driven Security Control for Networked Control Systems	Data-Driven Technique and its Industrial Application
18:00-20:00	Closing Ceremony and Banquet, Chair: Prof. Dong Shen					