The 15th IEEE Conference on
Industrial Electronics and Applications
(ICIEA 2020)

09-13 November 2020
Kristiansand, Norway

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Message from The General Chairs

On behalf of the Organising Committee, we would like to extend to you our warmest welcome to the 15th IEEE Conference on Industrial Electronics and Applications (ICIEA 2020), 9-13 November 2020, Kristiansand, Norway. Established in 2006, the ICIEA series of annual conferences have served as an excellent forum for scientists, researchers, engineers and industrial practitioners from around the world to network and to share the latest technology advancements and future trends in industrial electronics and its board applications. This year, it marks the 15th Anniversary of the ICIEA conferences.

ICIEA 2020 is organized by the University of Agder, Norway, the IEEE Industrial Electronics Chapter of Singapore, and the IEEE Singapore Section. It is sponsored both technically and financially by the IEEE Industrial Electronics Society.

Kristiansand is considered the capital of Southern Norway and the heart of the region. It is the fifth largest city in Norway, with 92,000 inhabitants. The city is home to global leaders in the oil and gas service industry, which has helped put Kristiansand on the world map and make Vest-Agder Norway’s largest export county per capita. Through innovation, this industry has successfully maintained its position in the global market. Kristiansand has been a driving force in promoting positive city and town development and was awarded Statens pris for Attraktiv By (the Government’s Attractive City Award) in 2018.

University of Agder (UiA) has 13,000 students and 1,400 faculty and staff members. It is one of the most modern universities in Norway, and it is still growing and consolidating its position for its high-quality research and study programs both on the national and international level. UiA seeks to be an open and inclusive university that is characterized by a culture of cooperation and aims to be on the cutting edge of innovation, education and research.

ICIEA 2020 received overwhelming responses with more than 510 submissions from 31 countries/regions. All submitted papers were processed by the Technical Program Committee and rigorously peer-reviewed by a select panel of international researchers. Its technical program consists of 342 papers arranged in 50 regular/invited/special sessions. In addition to the parallel technical sessions, there are three Keynotes to be delivered by internationally renowned professors and researchers. The official conference proceedings will be published by IEEE and included in the IEEE Xplore database.

We are extremely honoured to have Professor Miroslav Krstic from University of California San Diego, USA, Professor Haizhou Li from National University of Singapore, Singapore, and Professor Ing. Armando Walter Colombo from University of Applied Sciences Emden/Leer as the keynote speakers. We would like to express our sincere appreciation to our Keynote speakers for their support and contribution to ICIEA 2020.

It is our honour to have the opportunity to thank all organisers of the special sessions and invited sessions and the numerous researchers worldwide who have helped to review and comment the submitted papers. We are thankful for the invaluable advice, support and assistance rendered by the members of our distinguished International Advisory Committee. We would like to express our sincere acknowledgement of the technical sponsorship provided by the IEEE Industrial Electronics Society and IEEE Singapore Section.
We thank all delegates for your long-lasting and strong support, without which the success of ICIEA is not imaginable. We are grateful to our friends, colleagues and family members who have helped the conference directly or indirectly, one way or another.

We wish all of our delegates a fruitful, rewarding, enjoyable and memorable virtual conference experience on-line.

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Rui He  
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Xu Huang  
Xudong Ma  
Xusheng Yang  
Yajuan Sun  
Yan Xing  
Yang Li  
Yang Yang  
Yang Zhou  
Yanpeng Li  
Yao Qin  
Yao Sun  
Yashar Shabbouei Hagh  
Yating Zheng  
Ye Fei Chen  
Yihan Xu  
Yinfu Zhu  
Ying Bai  
Ying Zhou  
Ying-Chun Chuang  
Yipeng Lu  
Yong Zhang  
Yongcong Wu  
Yongli Liu  
Yu Ma  
Yudong Du  
Yue Guan  
Yue Wang  
Yueyang Zhang  
Yuhan Ji  
Yujing Huang  
Yukuan Yang  
Yuliang Jiang  
Yunfei Zhang  
Yunhong Zhou  
Yunhong Zhou  
Yunhua Li  
Yunlei Zhang  
Yuewei Zhang  
Zhangqiang Zhang  
Zhao Liu  
Zhaochen Li  
Zhaodong Chen  
Zhenbin Zhang  
Zheng Wang  
Zhengguo Li  
Zhengqun Xu  
Zhenwei CAO  
Zhenwei Ma
Panel of Reviewers

Zhenyi Shen
Zhihong Man
Zhijie Lian
Zhixin Ou

Zhixun Ma
Zhonghai Ma
Zhou Fang
Zijie Qi

Zilin Liang
Ziwen Xu
Ziyang Liu

Info-14
The 15th IEEE Conference on Industrial Electronics and Applications will be held during 9-13 November 2020, in Kristiansand, Norway. In addition to the regular technical sessions, there will be Keynote Speeches, Invited Lectures and Invited & Special Sessions.

Radisson Blu Caledonien Hotel
Vestre Strandgate 7,
Kristiansand, 4610, Norway.
Telephone: +47 38112100
https://www.radissonhotels.com/

Location

![Conference Location & Floor Plan](image-url)
General Information

The 15th IEEE Conference on Industrial Electronics and Applications was originally scheduled to be held from 21-25 June 2020 in Kristiansand, Norway. Due to uncertainties caused by COVID-19, the committee has decided to postpone the conference to 9-13 November 2020. After that, it was further decided to change from physical conference to fully virtual in July 2020.

Language
The conference and all its activities will be conducted in English.

Live Sessions

Time Zone UTC +1

Opening Ceremony
10 November 2020, 08:45 - 09:00 hrs

Keynote Speeches
Keynote 1 Session: 10 November 2020, 09:00 - 10:00 hrs
Keynote 2 Session: 10 November 2020, 10:00 - 11:00 hrs
Keynote 3 Session: 11 November 2020, 15:00 - 16:00 hrs

Best Paper Selection Session
11 November 2020, 09:00 - 11:00 hrs

Pre-recording Sessions
Total 54 pre-recording sessions technical sessions will be online for two weeks.
About Kristiansand, Norway

Kristiansand historically spelled Christiansand and Christianssand, is a city and municipality in Agder county, Norway. It is the fifth largest city in Norway and the municipality is the sixth largest in Norway, with a population of around 112,000 as of January 2020, following the incorporation of the municipalities of Søgne and Songdalen into the new and revised municipality of greater Kristiansand.[5] In addition to the city itself, Statistics Norway counts four other densely populated areas in the municipality: Skålevik in Flekkerøy with a population of 3,526 in the Vågsbygd borough, Strai with a population of 1,636 in the Grim borough, Justvik with a population of 1,803 in the Lund borough,[6] and Tveit with a population of 1,396 (as of January 2012) in the Oddernes borough. Kristiansand is divided into five boroughs: Grim, which is located northwest in Kristiansand with a population of 15,000; Kvadraturen, which is the centre and downtown Kristiansand with a population of 5,200; Lund, the second largest borough; Søgne, with a population of around 12,000 and incorporated into the municipality of Kristiansand as of January 2020; Oddernes, a borough located in the west; and Vågsbygd, the largest borough with a population of 36,000, located in the southwest.

To know more about, please visit: https://en.wikipedia.org/wiki/Kristiansand
The 15th IEEE Conference on Industrial Electronics and Applications (ICIEA2020) will be held during 9-13 November 2020, in Kristiansand, Norway. The Conference is organized by IEEE Industrial Electronics Chapter of Singapore, University of Agder, and IEEE Singapore Section. IEEE Industrial Electronics Society is the financial and technical sponsor.

Past Conferences

ICIEA 2007 — Harbin, China, 23–25 May 2007
ICIEA 2008 — Singapore, 3–5 June 2008
ICIEA 2009 — Xi’an, China, 25–27 May 2009
ICIEA 2017 — Siem Reap, Cambodia 18 – 20 June 2017: http://www.ieeeiciea.org/2017
ICIEA 2018 — Wuhan, China 31 May-2 June 2018: http://www.ieeeiciea.org/2018
ICIEA 2019 — Xi’an, China 19–21 June 2019: http://www.ieeeiciea.org/2019

Conference Tracks

Authors are invited to submit full papers describing original research work in areas including, but not limited to:


Control and Systems: Adaptive and intelligent control, Distributed and decentralized control, Games, Hybrid control, Networked control, Nonlinear systems, Optimization and optimal Control, Predictive control, Process control, Robust control, System identification and filtering, Uncertain systems, Control system applications.

Cyber-physical Systems: Smart grid, Intelligent transportation systems, Internet of things, Mobile healthcare, Distributed computing, Infrastructure simulations, Security and privacy, Data integration and visualization, New sensing platform and sensors computing.


Industrial Informatics and Computational Intelligence: Human-machine interactions, Diagnosis and prognosis, Intelligent automation, Networked embedded controllers, Machine-to-machine, Condition based maintenance, Multi-agent systems, Fuzzy systems, Genetic algorithm, Evolutionary computing, Data mining.


Network and Communication: Network protocols, Mobile computing, Mobile ad hoc networks, Mobile agents, Network architectures, Quality of services, Cross-layer design/optimization, Design and performance evaluation, Traffic control, Wireless systems, MU-MIMO systems, Optoelectronics and Optical Communication.

Power Electronics: Power devices and components, Power quality control, FACTS, PFC, STATCOM, Harmonic analysis
and compensations, Switching circuits and power converters, Motors and drives, Smart grid, Distribution generation and electrical vehicles, Wireless power transmission, Energy harvesting.

Signal and Information Processing: Image processing, Computer vision, Bio-image processing, Audio/video processing, Data processing, Estimation and identification, Remote sensing, Information fusion, Brain computer interface, Signal transforming and filtering, Digital system design and structures, Optimization techniques.

Invited and Special Sessions: The Technical Program Committee is soliciting proposals for invited and special sessions focusing on topics relevant to the theme of the conference. Prospective organizers should submit proposals to the Invited Session Chairs, Prof. Weihai Chen (whchenbuaa@126.com), Prof. Fanglin Luo (luofanglin@ahu.edu.cn), Prof. Martin Choux (martin.choux@uiu.no), Prof. Ilya Tyapin (ilya.tyapin@uiu.no), Prof. Morten Kjeld Ebbesen (morten.k.ebbesen@uiu.no) or Prof. Chenguang Yang (Charl. Yang@uwe.ac.uk) by the date listed in “Important Dates”. 
Keynote Speeches
Keynote Speech I

Date/Time: November 10, 2020 (Tuesday) / 09:00 - 10:00 hrs
Venue/Room:

DIN SPEC 91345 RAMI4.0-based Engineering of Industrial Cyber-Physical Systems

Professor Dr.-Ing. Armando Walter Colombo
The Department of Electrotechnical and Industrial Informatics at the University of Applied Sciences Emden-Leer, Germany

Biography

Professor Dr.-Ing. Armando Walter Colombo joined the Department of Electrotechnical and Industrial Informatics at the University of Applied Sciences Emden-Leer, Germany, became Full Professor in August 2010 and Director of the Institute for Industrial Informatics, Automation and Robotics (I2AR) in 2012.

Prof. Colombo worked also during the last 17 years as Manager for Collaborative Projects and also as Edison Level 2 Group Senior Expert at Schneider Electric, Industrial Business Unit.

Prof. Colombo received the BSc. on Electronics Engineering from the National Technological University of Mendoza, Argentina, in 1990, the MSc. on Control System Engineering from the National University of San Juan, Argentina, in 1994, and the Doctor degree in Engineering from the University of Erlangen-Nuremberg, Germany, in 1998. From 1999 to 2000 was Adjunct Professor in the Group of Robotic Systems and CIM, Faculty of Technical Sciences, New University of Lisbon, Portugal.

Prof. Colombo has extensive experience in managing multi-cultural research teams in multi-regional projects. He has participated in leading positions in many international research and innovation projects. His research interests are in the fields of industrial cyber-physical systems, industrial digitalization and system-of-systems engineering, Internet-of-Services, Industry 4.0-compliant solutions.

Prof. Colombo has over 30 industrial patents and more than 300 peer-review publications in journals, books, chapters of books and conference proceedings. With his contributions, he has performed scientific and technical seminal contributions that are nowadays being used as one of the basis of what is recognized as ‘The 4th Industrial Revolution’ and are penetrating the daily life, producing visible societal changes and impacting all levels of the society. He is co-founder of three IEEE IES Technical Committees (i) on Industrial Agents, (ii) on Industrial Informatics and (iii) on Industrial Cyber-Physical Systems. He is also member of the IEEE IES Administrative Committee (AdCom).

Prof. Colombo served/serves as advisor/expert for the definition of the Research and Innovation priorities within the Framework Programs FP6, FP7 and FP8 (HORIZON 2020) of the European Union, and he is working as expertvaluator in the European Research Executive Agency (REA), ECSEL Platform, Eureka- and German BMBF/DLR Programs, as well as Digital Supercluster Canada, National R&D-Programs in Sweden, Denmark, Italy, Switzerland, etc.

Prof. Colombo is listed in Who’s Who in the World/Engineering 99-00/01 and in Outstanding People of the XX Century (Bibliographic Centre Cambridge, UK).

Abstract

Industry 4.0 is a collective term for technologies, concepts and novel business approaches, formalized under the DIN Specification 91345 RAMI4.0, that covers the whole industrial value chain, combining Cyber-Physical
Keynote Speeches

Systems, the Internet-of-Things and the Internet-of-Services. After presenting the scientific and technical background behind Industrial-Cyber-Physical Systems (ICPS), the audience/participants of the Plenary Keynote will get a deep view about: – Digitalization and Networking of the economy. Principles. – Building industrial eco-systems of digitalized and networked things/assets. Industry 4.0. – Formalizing the digitalization and networking principles with the DIN Specification 91345 RAMI4.0 – Understanding why and how to navigate the 3D-model RAMI4.0 in order to fulfilling the major requirements for engineering the digitalization of the industrial value stream and the life cycle of ICPS? – Understanding how to migrate from Industry 3.0 to Industry 4.0 environments. Analysis and discussion of results of exemplary innovation projects. – Overviewing a core curriculum for educating engineers at Master Level in Industry4.0 / Industrial Cyber-Physical Systems. Master on Industrial Cyber-Physical Systems of the DAAD / CUAA-DAH, Germany-Argentina.
Date/Time: November 10, 2020 (Tuesday) / 10:00 - 11:00 hrs

Venue/Room:

Keynote Speech II

Speech Processing at Cocktail Party

Professor Haizhou Li

Department of Electrical and Computer Engineering, National University of Singapore, Singapore
Bremen Excellence Chair Professor, University of Bremen, Germany

Biography

Haizhou Li is a Professor at the Department of Electrical and Computer Engineering, National University of Singapore, and a Bremen Excellence Chair Professor at the University of Bremen, Germany. His research interests include speech information processing, natural language processing, and neuromorphic computing. Professor Li has served as the Editor-in-Chief of IEEE/ACM Transactions on Audio, Speech and Language Processing (2015-2018), the President of the International Speech Communication Association (ISCA, 2015-2017), and the President of Asia Pacific Signal and Information Processing Association (APSIPA, 2015-2016). He is a Fellow of the IEEE and the ISCA.

Abstract

Humans have a remarkable ability to pay their auditory attention only to a sound source of interest, that we call selective listening, in a multi-talker environment or a Cocktail Party. However, signal processing approach to speech separation and/or speaker extraction from multi-talker speech remains a challenge for machines. In this talk, we study the deep learning solutions to monaural speech separation and speaker extraction that enable selective listening, speech recognition, speaker recognition at Cocktail Party. We discuss the computational auditory models, technical challenges and the recent advances in the field.
Date/Time: November 11, 2020 (Wednesday) / 15:00 - 16:00 hrs
Venue/Room:

**Keynote Speech III**

**Extremum Seeking and its Applications**

Professor Miroslav Krstic

*Mechanical and Aerospace Engineering, Director of the Cymer Center for Control Systems and Dynamics, UC San Diego, USA*

**Biography**

Miroslav Krstic is Distinguished Professor of Mechanical and Aerospace Engineering, holds the Alspach endowed chair, and is the founding director of the Cymer Center for Control Systems and Dynamics at UC San Diego. He also serves as Senior Associate Vice Chancellor for Research at UCSD. As a graduate student, Krstic won the UC Santa Barbara best dissertation award and student best paper awards at CDC and ACC. Krstic has been elected Fellow of seven scientific societies – IEEE, IFAC, ASME, SIAM, AAAS, IET (UK), and AIAA (Assoc. Fellow) – and as a foreign member of the Serbian Academy of Sciences and Arts and of the Academy of Engineering of Serbia. He has received the SIAM Reid Prize, ASME Oldenburger Medal, Nyquist Lecture Prize, Paynter Outstanding Investigator Award, Ragazzini Education Award, IFAC Nonlinear Control Systems Award, Chestnut textbook prize, Control Systems Society Distinguished Member Award, the PECASE, NSF Career, and ONR Young Investigator awards, the Schuck (’96 and ’19) and Axelby paper prizes, and the first UCSD Research Award given to an engineer. Krstic has also been awarded the Springer Visiting Professorship at UC Berkeley, the Distinguished Visiting Fellowship of the Royal Academy of Engineering, and the Invitation Fellowship of the Japan Society for the Promotion of Science. He serves as Editor-in-Chief of Systems & Control Letters and has been serving as Senior Editor in Automatica and IEEE Transactions on Automatic Control, as editor of two Springer book series, and has served as Vice President for Technical Activities of the IEEE Control Systems Society and as chair of the IEEE CSS Fellow Committee. Krstic has coauthored thirteen books on adaptive, nonlinear, and stochastic control, extremum seeking, control of PDE systems including turbulent flows, and control of delay systems.

**Abstract**

Extremum seeking (ES) is a method for solving optimization problems without the knowledge of the operating map, using only the measurements of the output of the map. Tackling similar problems as evolutionary/genetic algorithms, ES was invented half a century earlier within the early control community and is well suited for real-time implementation on plants with significant dynamics. Modern ES algorithms, developed since 2000, are capable of guaranteeing stability, and even prescribed rates of convergence in spite of the plant model and the performance index function being unknown. I will overview some fundamental ES results, including deterministic and ES algorithms, ES for non-cooperative games, and extensions of ES from gradient to Newton based updates. Many hundreds of applications of ES have emerged since 2000. I will highlight source seeking for autonomous vehicles in GPS-denied environments, MPPT for solar and wind energy sources, liquid tin droplet targeting by lasers in semiconductor photolithography, and a Mars Rover application.
ICIEA 2020 Technical Programme

Session | [LS01]: Best Paper Award Selection
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P1310 | Pg 3
MegaSense: Cyber-Physical System for Real-time Urban Air Quality Monitoring
Andrew Rebeiro-Hargrave, Naser Hossein Motlagh, Samu Varjonen, Eemil Lagerspetz, Petteri Nuutila and Sasu Tarkoma
Department of Computer Science, University of Helsinki, Helsinki, Finland.

P1498 | Pg 3
Model Predictive Control and Disturbance Compensation for Engine Test Beds
Dennis Erdogan, Stefan Jakubek and Christoph Hametner
1Christian Doppler Laboratory for Innovative Control and Monitoring of Automotive Powertrain Systems, TU Wien, Vienna, Austria. 2Institute of Mechanics and Mechatronics, TU Wien, Vienna, Austria.

P1516 | Pg 3
A Novel High Frequency Isolated Three-Level Inverter and Its Topological Derivation Method
Yue Guan, Lei Li and Jinchuan Zhang
School of Automation, Nanjing University of Science and Technology, Nanjing, China.

P1517 | Pg 4
Adaptive Weighted Robust Principal Component Analysis
Zhengxin Xu, Yang Lu, Jiaxing Wu, Rui He, Shujian Wu and Shouli Xu
1School of Machinery and Automation, Institute of Robotics and Intelligent Systems, Wuhan University of Science and Technology, Wuhan, China. 2Signal Processing, RF & Optical Dept., Institute for Infocom Research, A*STAR, Singapore.

P1586 | Pg 4
A Temporal Forecasting Driven Approach Using Facebook’s Prophet Method for Anomaly Detection in Sewer Air Temperature Sensor System
Karthick Thiyagarajan, Sarath Kodagoda, Nalika Ulapane and Mukesh Prasad
1Pipes Lab, UTs Robotics Institute, University of Technology Sydney, Sydney, Australia. 2School of Electrical and Electronic Engineering, University of Melbourne, Melbourne, Australia. 3Centre for Artificial Intelligence, University of Technology Sydney, Sydney, Australia.

P1602 | Pg 4
Model Predictive Power Control with Current Stress Optimization for Bidirectional Series Resonant DC/DC Converter
Wensheng Song, Ming Zhong and Shuqiong Luo
School of Electrical Engineering, Southwest Jiaotong University, Chengdu 610031, China.

Session | [TT01]: Industrial Informatics & Computational Intelligence (I)
P1071 | Pg 5
Design of a Shared Platform for Interactive Public Art from Perspective of Dynamic Vision
Zhang Nan, Zhang Fan and Enmao Liu
1Department of Public Art, Beijing Institute of Fashion Technology, Beijing, China. 2Department of Industrial Design, Beijing Institute of Fashion Technology, Beijing, China. 3College of Computer Science and Technology, Zhejiang University, Hangzhou, China.

P1013 | Pg 5
Summary of Pedestrian Traffic Statistics Research
Jian Sheng and Zhi Zhang
1Collage of Computer Science and Technology, Wuhan University of Science and Technology, Wuhan 430065, Hubei, China. 2Hubei Province Key Laboratory of Intelligent Information Processing and Real-time Industrial System, Wuhan, China, 430065, Hubei, China. 3Big Data Science and Engineering Research Institute, Wuhan University of Science and Technology, Wuhan, China, 430065, Hubei, China.

P1544 | Pg 5
Multiple Screen Control Application with Facial and Gesture Recognitions in a Manufacturing Control Room
Zhengjin Guo, Wilfred Kang Chee Wong, Kyaw Sett Myo and Weng Xian Choong
1Advanced Remanufacturing and Technology Center (ARTC), Agency for Science, Technology and Research (A*Star), Singapore. 2Singapore Polytechnic (SP), Singapore.
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<td>Design of a Novel Device for Measuring the Inertia of Helmet</td>
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<td></td>
<td>Xiao Chen¹, Cong Zhang², Wei Zhang³, Chuang Ma² and Jianwei Niu²</td>
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<td>¹Institute of System Engineering, Academy of Military Science, People's Liberation Army Beijing, China. ²School of Mechanical Engineering, University of Science and Technology Beijing, Beijing, China. ³School of Mechanical Engineering, Beihang University, Beijing, China.</td>
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<tr>
<td>P1055</td>
<td>Int-Papercut: An Intelligent Pattern Generation with Papercut Style Based on Convolutional Neural Network</td>
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<td>Enmao Liu¹, Lijuan Liu¹, Junwu Wang², Qiming Jin³, Cheng Yao³ and Fangtian Ying³</td>
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<td>¹Collage of Computer Science and Technology, Zhejiang University, Hangzhou, China. ²School of Industrial Design, Hubei University of Technology, Wuhan, China. ³Product Research and Development Department, Co-share Educational Tech Hangzhou, China.</td>
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<tr>
<td>P1036</td>
<td>Improve Performances of a Laser Tracking System by Adopting a Modified Fuzzy Neural Network Controller</td>
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<td>Ying Bai¹ and Dali Wang²</td>
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<td>¹Dept. of Computer Science and Engineering, Johnson C. Smith University, Charlotte, USA. ²Dept. of Physics and Computer Science, Christopher Newport University, Newport News, USA.</td>
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<td>P1023</td>
<td>Device Target Checking for Power Patrol Robot Based on Objectness Estimation</td>
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<td>Nauheen Saeed¹, Mark Dougherty²,³, Roger G. Nyberg¹, Pascal Rebreyend¹ and Dania Jomaa²</td>
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<tr>
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<td>¹Faculty of Data &amp; Information Sciences, Dalarna University, Borlänge, Sweden. ²School of Information Technology, Helmut University, Halmstad, Sweden.</td>
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ICIEA 2020 — Technical Programme

P1459
Fault Diagnosis of Subway Plug Door Based on Isomap and GWO-SVM
Yang Liu1, Dong Liu1, ChenXi Li1, Yiyang Wang2, Juyanuo Yang1 and Qilong Jiang1
1School of Electrical Engineering, Southwest Jiaotong University, Chengdu, China. 2Leeds Joint School, Southwest Jiaotong University, Chengdu, China.

P1612
Adaptive Multi-Layer Structure for Anomaly Detection in Hyperspectral Images
Hongmei Yan and Mingyi He
Northwestern Polytechnical University, Xian, China, 710129.

P1616
Fault-Tolerant Application Mapping on to ZMesh Topology based Network-on-Chip Design
P. Veda Bhamu1, Nikita Mandapati1, Soumya J1 and Linga Reddy Cenkeramaddi
1Department of Electrical and Electronics Engineering, BITS-Pilani, Hyderabad Campus, Hyderabad, Telangana, India 500078. 2Department of Information and Communication Technology, University of Agder, Norway.

P1568
A Densely Connected Face Super-Resolution Network based on Attention Mechanism
Ying Liu1, Zhanlong Dong2, Keng Pang Lim2 and Nam Ling2
1Ministry of Public Security, Key Laboratory of Electronic Information Application, Technology for Scene Investigation, Xi’an Shaanxi, China. 2Xi’an University of Posts & Telecommunications, Center for Image and Information Processing, Xi’an Shaanxi, China. 3Santa Clara University, Department of Computer Science and Engineering, Santa Clara, CA, USA.

P1038
Anomaly Detection of Heat Energy Usage in District Heating Substations Using LSTM based Variational Autoencoder Combined with Physical Model
Fan Zhang1 and Hasan Fleyeh2
1Dalarna University, Departments of Energy Technology and Microdata Analysis Falun, 79188, Sweden. 2Dalarna University, Department of Computer Engineering, Falun, 79188, Sweden.

P1497
A Review on Data Analysis of Bitcoin Transaction Entity
He Xi1, Zhang Fan2, Lin Shenwen3, Mao Hongliang3 and He Ketai1
1School of Mechanical Engineering, University of Science and Technology Beijing, Beijing, China. 2School of Computer & Communication, Engineering, University of Science and Technology Beijing, Beijing, China. 3National Computer Network, Emergency Response Technical, Team/Coordination Center of China, Beijing, China.

P1501
The Effect of Hatch Angles on the Microstructure and Mechanical Properties of Selective Laser Melting 316L Stainless Steel
Zhou liu, He Ketai and Hu Qingqiang
School of Mechanical Engineering, University of Science and Technology Beijing, Beijing, China.
### ICIEA 2020 — Technical Programme

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| A Periodic Event-Triggering Reactive Power Sharing Control in an Islanded Microgrid considering DoS Attacks | Bingyu Wang, Qiuye Sun and Dazhong Ma  
College of I.E.S., Northeastern University, Shenyang, China. |

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| A Data Mining Framework to Predict Cyber Attack for Cyber Security | Md Anisur Rahman, Yeslam Al-Saggaf and Tanveer Zia  
School of Computing and Mathematics, Charles Start University, Australia. |

### Session [TT06]: Cyber-physical Systems (II)

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| Image Encryption Based on Fractional-Order Chen Hyperchaotic System | Jun Peng1,2, Wu Yang3, Shangzhao Jin3, Shaoming Pang1, Dedorong Tang4, Jieqian Bai6 and Du Zhang5  
1School of Intelligent Technology and Engineering, Chongqing University of Science and Technology, Chongqing 401331, China. 2School of Computer Science and Engineering, Chongqing University of Technology, Chongqing 400064, China. 3School of Science, Engineering and Information Technology, Federation University Australia, Ballarat, Victoria, Australia. 4School of Electrical Engineering, Chongqing University of Science and Technology, Chongqing 401331, China. 5Faculty of Information Technology, Macau University of Science and Technology, Macau, China. |

### Session [TT05]: Cyber-physical Systems (I)

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| An Indoor Positioning Approach Using Smartphone Based on PDR and EKF | Xianshan Li, Yurun Shao and Fengda Zhao  
College of Information Science and Engineering, Yanbian University, Qiqihar, China. |

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| Research on RLGA-Based Hardware Evolution Optimization Technology | Min Zhu1, Sheng Yi1, Chunling Yang2 and Hongwei Feng2  
1Harbin Institute of Technology, School of Electrical Engineering, Harbin, China. 2Beijing Orient Institute of Measurement and Test, Beijing, China. |

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| Research on Task Decomposition and Optimization Methods of Cyber Physical Systems | Xiaodong Wang, Yangming Guo, Huan Yang, Zhaqing Wang, Yuan Li, Nan Lu, Yan Zhang and Zhuya Zou  
School of Computer Science, NorthWestern Polytechnical University, Xi'an, China. |

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| Numerical Modeling of the Effects of Electrode Spacing and Multi-layered Concrete Resistivity on the Apparent Resistivity Measured Using Wenner Method | Kartik Thiyagarajan, Parikhhit Acharya, Lasitha Piyathilaka and Sarath Kodagoda  
iPipes Lab, UTS Robotics Institute, Faculty of Engineering and Information Technology, University of Technology Sydney, Sydney, Australia. |

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Bin Li1, Liang Yan1, Liqin Zhang3 and Christopher Gerada2
1School of Automation Science and Electrical Engineering, Beihang University, Beijing, China. 2Department of Electrical and Electronic Engineering, University of Nottingham, Nottingham, UK.

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1College of Engineering and Science, Victoria University, Victoria 801, Melbourne, Australia. 2College of Mathematics and Computer Science, Yan’an University, Yan’an, 716000, P. R. China.

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1Navigation College, Dalian Maritime University, Dalian, Liaoning, China. 2Faculty of Navigation, Vietnam Maritime University, Haiphong, Vietnam. 3School of Automation Engineering, University of Electronic Science and Technology of China, Chengdu, Sichuan, China.

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1Shenyang Institute of Computing Technology, Chinese Academy of Sciences, Shenyang, Liaoning, P. R. China, 110016. 2University of Chinese Academy of Sciences, Chinese Academy of Sciences, Beijing, P. R. China, 100049. 3School of Electromechanical and Automotive Engineering, Yantai University, Yantai, Shandong Province, China.

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1School of Automation Science and Electrical Engineering, Beihang University, Beijing, China. 2Department of Electrical and Electronic Engineering, University of Nottingham, Nottingham, UK.

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1College of Electrical Engineering, Zhejiang University, Hangzhou, China. 2State Grid Zhejiang Electric Power Co., Ltd, Hangzhou, China.
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1School of Control Science and Engineering, Shandong University Jinan, China 250061. 2Key Laboratory of Systems and Control, Academy of Mathematics and Systems Sciences, Chinese Academy of Sciences, Beijing, 100190.

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1School of Electrical Engineering, Southwest Jiaotong University, Chengdu, China 2University of Leeds Joint School, Southwest Jiaotong University, Chengdu, China.
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\textsuperscript{1}Institute of Robotics and Intelligent Systems, School of Information Science and Engineering, Wuhan University of Science and Technology, Wuhan, China. \textsuperscript{2}School of Intelligent Technology and Engineering, Chongqing University of Science and Technology, Chongqing, China.

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1State Grid Yangzhou Power Supply Company, Yangzhou, China. 2School of Electrical Engineering, Southeast University, Nanjing, China. 3China Electric Power Research Institute (Nanjing), Nanjing, China.

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1Department of Electrical Engineering, Harbin Institute of Technology, Harbin, China. 2Tritium Pty Ltd, Brisbane, Australia.

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1Department of Electric Power Engineering, Norwegian University of Science and Technology, Trondheim, Norway. 2Department of Engineering Cybernetics, Norwegian University of Science and Technology, Trondheim, Norway.

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College of Automation Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing 211106, China.

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College of Automation Engineering, Nanjing University of Aeronautics & Astronautics, Nanjing, China.

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Research on Control Strategy of Photovoltaic Grid Connected Converter Under Voltage Distortion
Chuncheng-Han1, Zhenyu-Shi2, Huan-He1, Junde-Liu1 and Yang-Cao1
1State Grid Anshan Power Supply Company, Anshan 114000, China. 2School of Electrical Engineering, Northeast Electric Power University, Jinlin 130212, China.
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<td>School of Automation, Beijing Institute of Technology, Beijing, China.</td>
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<td>School of Electrical Engineering and Automation, Anhui University, Hefei, China. Collaborative Innovation Center of Industrial Energy-Saving and Power Quality Control, Anhui University, Hefei, China.</td>
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<td>1School of Electrical Engineering and Automation, Anhui University, Hefei, China. 2Collaborative Innovation Center of Industrial Energy-Saving and Power Quality Control, Anhui University, Hefei, China. 3Engineering Research Center of Power Quality, Ministry of Education, Anhui University, Hefei, China.</td>
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<td>1School of Electrical and Power Engineering, China University of Mining and Technology, No.1, University Road, Xuzhou, 221116, China. 2Department of Electronics Engineering, University of York, York, United Kingdom.</td>
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Yuanyuan Lei\(^1\), Jie Zhou\(^2\), Jiazhu Xu\(^2\), Linjie Zhao\(^3\) and Qingmin Xin\(^1\)
\(^1\)Electric Power Research Institute, China Southern Power Grid Company Limited, Guangzhou, China. \(^2\)College of Electrical and Information Engineering, Hunan University, Changsha, China.

### An Improved Human-Simulated Intelligent Control Algorithm for Bidirectional DC-DC Converter
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College of Automation, Nanjing University of Science and Technology, Nanjing, China.

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\(^1\)Southeast University, Nanjing, China. \(^2\)China Electric Power Research Institute, Beijing, China.

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Fuming Deng, Xiaoli Meng, Liang Peng, Xu and Zhen Liu
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Hongpeng Zhang\(^1\), Guoqiang Zhang\(^2\), Wen Shen\(^2\), Gaolin Wang\(^1\) and Dianguo Xu\(^1\)
\(^1\)School of Electrical Engineering and Automation, Harbin Institute of Technology, Harbin, China. \(^2\)INVT, Shenzhen, China.

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Cheng Zhou\(^1,2\) and Changbao Zheng\(^1\)
\(^1\)Collaborative Innovation Center of Industrial Energy-saving and Power Quality Control, Anhui University, Hefei, China. \(^2\)College of Information Engineering, Anhui Institute of International Business, Hefei, China.
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State Key Laboratory of Power Transmission Equipment and System Safety and New Technology, Changqing University, 400044, China.

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Yao Wang1,2, Limei Xu1, Liuyang Zhang2 and Ling Chen3
1School of Electrical and Informatics Engineering, Southwest Minzu University, 2School of Electrical Engineering, Southwest Jiaotong University, Chengdu, China.

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Key Laboratory of Magnetic Suspension Technology and Maglev Vehicle Ministry of Education School of Electrical Engineering, Southwest Jiaotong University, Chengdu, People’s Republic of China.

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Ajit Jha1 and Santiago Royo2
1Department of Engineering Sciences, University of Agder, Grimstad, Norway. 2Center for Sensors, Instruments and System Developments, Technical University of Catalunya, Terrassa, Spain.
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1 School of Safety Engineering, Chongqing University of Science and Technology, Chongqing 401331, China.
2PetroChina Zhejiang Oilfield Company, Hangzhou 310013, China.
3Chongqing Institute of Geology and Mineral Resources, Chongqing 401223, China.

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Joseph E. Dinardo, Z.C. Feng, and P. Frank Pai
Mechanical and Aerospace Engineering, University of Missouri Columbia, MO 65211, USA.

Development of Portable Balance Rate Tester for Sucker Rod Pumping Unit
Li Hangzhang and Panyu Shengli College, China University of Petroleum, Dongying 257061, China.

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Zhibin Yu1, Yuxin Wang1, and Chenxia Chen2
1 School of Electrical Engineering, Southwest Jiaotong University, Chengdu, China.
2 School of Economics and Management, Chengdu Technological University, Chengdu, China.

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Shahriar Saleque, Gol-A-Zannat Spraha, MA Rasheeq
Department of Signal Processing and Machine Learning, Brac University, Dhaka, Bangladesh.

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Department of Engineering, Durham University, Durham, United Kingdom.
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1Department of Electrical and Electronics Engineering, BITS-Pilani, Hyderabad Campus, Hyderabad, Telangana, India 500078. 2Department of Information and Communication Technology, University of Agder, Norway.

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Fan Zhang1, Cuiqin Lan1, Tao Wang2, Feng Cao3 and Emmao Liu4
1Department of Industrial Design, Beijing Institute of Fashion Technology, Beijing, China. 2Fashion Accessory Art and Engineering College, Beijing Institute of Fashion Technology, Beijing, China. 3Creative Design Center, Alibaba Inc, Hangzhou, China. 4College of computer science and technology, Zhejiang University, Hangzhou, China.

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Pinggang Duan1, Xiaohui Li1, Yuemin Ding2 and Zhenxing Liu1
1School of information Science and Engineering, Wuhan University of Science and Technology, Wuhan, 430081, China. 2School of Computer Science and Engineering, Tianjin University of Technology, Tianjin, 300384, China.

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School of Computing & Mathematical Sciences, University of Greenwich, London, United Kingdom.
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JiaLu Du, ZhiGuang Wang and Qiang Zhou
School of Automation Science and Electrical Engineering, Beihang University, Beijing, China.

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Yukuan Yang1,2, Lei Deng3, Peng Jiao1, Yansong Chua4, Jing Pu2, Cheng Ma1,2 and Guoqi Liu1,2
1Department of Precision Instrument, Center for Brain Inspired Computing Research, Tsinghua University, Beijing 100084, China
2Beijing Innovation Center for Future Chip, Tsinghua University, Beijing, 100084, China
3Department of Electrical and Computer Engineering, University of California, Santa Barbara, CA 93106, USA
4Institute for Infocomm Research (I2R), A*STAR, Singapore, 138632, Singapore

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Hansen Liu1, Kuangang Fan2 and Bing He1
1School of Mechanical and Electrical Engineering, Jiangxi University of Science and Technology, Ganzhou, China.
2School of Electrical Engineering and Automation, Jiangxi University of Science and Technology, Ganzhou, China.

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Department of Computer Science and Engineering, Chongqing University of Technology, Chongqing, China.

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University of Agder, Norway, MacGregor Norway AS, Norway

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School of Computer Science and Engineering, Chongqing University of Technology, Chongqing, China.

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Askhat Diveev1 and Oubai Hussein2
1Dept. Control of Robotics, Federal Research Center, “Computer Science and Control” of Russian Academy of Sciences, Moscow, Russia
2Dept. Mechanics and Mechatronics, Peoples’ Friendship University of Russia, RUDN University, Moscow, Russia.

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1Dept. of Information and Communication Technology, University of Agder, Grimstad, Norway
2Dept. of Electrical Engineering, Indian Institute of Technology, Indore, India

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Department of Electrical Engineering, Northeast Electric Power University, Jilin, China.

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Yongtao Yuan¹, Xiangqian Tong¹, Jingjing Huang², Wei Zhang⁴, Jianfeng Xiao⁴ and Leong Hai Koh⁵
¹Department of Electrical Engineering, Xi’an Jiaotong University, Xi’an, China. ²School of Electronic and Information Engineering, Xi’an Jiaotong University, Xi’an, China. ³Newcastle University in Singapore (NUiS). ⁴Energy Research Institute @NTU Nanyang Technological University.

I&I Adaptive Based Backstepping Passive Coordination Control of STATCOM and Generator Excitation
Chaofan Du, Lei Zhang, Jiahao Zhu and Xingpeng Bo
School of Electronic and Information, Xi’an Polytechnic University, Xi’an, China.

Adaptive Control of a Voltage-Controlled Magnetic Levitation System with K-filter
Zhengqiang Zhang and Zhenwei Ma
Shool of Engineering, Qufu Normal University, Rizhao, P. R. China.

Fault Detection, Isolation and Estimation for Linear Systems with Partial Disturbance Decoupling
Zhao Zhang¹, Muherg Wei² and Xiao He³
¹Department of Automation, Tsinghua University, Beijing, China. ²ZhenDai Industry Artificial Intelligent Co., Ltd., Beijing, China.
Adaptive Fuzzy Finite-time Control for Switched Nonlinear Inverted Pendulum Systems
Yanli Fan, Tingting Yang and Yongming Li
1College of Electrical Engineering, Liaoning University of Technology, Jinzhou, China. 2College of Science, Liaoning University of Technology, Jinzhou, China.

Self-Triggered Control for Nonlinear Systems: A New Design Scenario From the Control Signal Perspective
Lantao Xing, Changyun Wen, Yu-Chu Tian and Yang Yang
1School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore. 2School of Electrical Engineering and Computer Science, Queensland University of Technology, GPO Box 2434, Brisbane QLD 4001, Australia 3College of Automation and College of Artificial Intelligence, Nanjing University of Posts and Telecommunications, Nanjing 210023, China

Terminal Sliding Mode Control for Spatial Descent of a Stratospheric Airship
Yifei Zhang, Ming Zhu, Tian Chen and Zewei Zheng
1School of Aeronautic Science and Engineering, Beihang University, Beijing 100191, P.R.China. 2Institute of Unmanned System, Beihang University, Beijing 100191, P.R.China.

Event-Based Formation Control for Linear Multi-Agent Systems Under Switching Topology
Guoliang Zhu, Kexin Liu, Haibo Gu and JinHu Li
School of Automation Science and Electrical Engineering, Beihang Advanced Innovation Center for Big Data and Brain Computing, Beihang University Beijing, China.

Event-triggered Adaptive Output Consensus Tracking Control of Uncertain Nonlinear Multi-agent Systems
Jiang Long, Wei Wang, Jiangshuai Haang and Lei Wang
1School of Automation Science and Electrical Engineering, Beihang University Beijing, China. 2School of Automation Science and Electrical Engineering, Beihang Advanced Innovation Center for Big Data and Brain Computing, Beihang University Changing, China.

Adaptive Leaderless Consensus for a Class of Uncertain Nonlinear Systems with Intermittent Actuator Faults
Marwah Saad Mahdi AL-Adhami, Jiang Long, Wei Wang and Lei Wang
1School of Automation Science and Electrical Engineering, Beihang University Beijing, China. 2School of Automation Science and Electrical Engineering, Beihang Advanced Innovation Center for Big Data and Brain Computing, Beihang University Beijing, China.

Event-Triggered Adaptive Control for a Class of Nonlinear Systems with Unknown Time-Varying Parameters
Wensiu Zhuang, Jing Zhou, Zhitao Liu and Hongye Su
1State Key Laboratory of Industrial Control Technology, Institute of Cyber-Systems and Control Zhejiang University, Hangzhou, China 2Department of Engineering Sciences, University of Agder, Grimstad, Norway.

Distributed Adaptive Cooperative Control for a Class of Nonlinear Multi-Agent Systems with Input Saturation
Ming Xiao, Zhitao Liu and Hongye Su
State Key Laboratory of Industrial Control Technology, Institute of Cyber-Systems and Control Zhejiang University, Hangzhou, China, 310027.

Robustness Improvement of Deadbeat Model Predictive Control for Five-phase PMSM Drives
Mahmoud S. R. Saeed, Wensheng Song and Bin Yu
School of Electrical Engineering, Southwest Jiaotong University, Chengdu 610031, Sichuan, China.

Improved Imaginary Axis Current Estimation for Single-phase Voltage Source Converters
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Model Predict Torque Control of Induction Motor Based on the DTC Switching Table
Chaoqun Xiang1, Xinan Zhang2, Zhuoxin Li1, Lulin Zhang1 and Shu Cheng1
1School of Electrical Engineering, Southwest Jiaotong University, Chengdu 610031, Sichuan Province, China. 2Electrical & Information Engineering Department, Sichuan Engineering Technical College, Deqang 618000, Sichuan Province, China

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School of Electrical Engineering, Southwest Jiaotong University, Chengdu, China.

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1School of Electrical Engineering, Southwest Jiaotong University, Chengdu, China. 2School of Electrical Engineering, Southwest Jiaotong University, Chengdu, China.

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Lili Zhai1, Qilong Jiang1, Yue Chen1, Fen Liang1 and Weifeng Yao2
1School of Electrical Engineering, Southwest Jiaotong University, Chengdu, China. 2School of Electrical Engineering, Southwest Jiaotong University, Chengdu, China.

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Shiqiang Xiang1, Shuting Li1, Songrong Wu1 and Zizhan Li2
1Key Laboratory of Magnetic Suspension Technology and Maglev Vehicle, Ministry Of Education School Of Electrical Engineering, Southwest Jiaotong University Chengdu, China. 2Pre-sales technical support department KeHua Heng Sheng Co., Ltd, Xiamen, China.
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<td>¹Key Laboratory of Magnetic Suspension Technology and Maglev Vehicle Ministry of Education, Southwest Jiaotong University, Chengdu, People’s Republic of China. ²Key Laboratory of Magnetic Suspension Technology and Maglev Vehicle Ministry of Education, School of Electrical Engineering, Tanshan, People’s Republic of China.</td>
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<td>Yingguang Chu¹, Guoyuan Li² and Houxiang Zhang³</td>
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<td>¹Sintef Ålesund AS, Ålesund, Norway. ²Department of Ocean Operations and Civil Engineering, Norwegian University of Science and Technology, Ålesund, Norway. ³Department of Ocean Operations and Civil Engineering, Norwegian University of Science and Technology, Ålesund, Norway.</td>
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|         | Junhong Zhou, Yu Wang and Yong Quan Chua |
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<td>Yuhao Cao1, Tengpeng Chen1, Lu Sun2, Yuhao Sun3, Zhonghao Wei4 and Gehan A. J. Amaratunga5</td>
<td>1Department of Instrumental and Electrical Engineering, Xiamen University, Xiamen, China. 2Experimental Power Grid Centre (EPGC), Nanyang Technological University, Singapore. 3CTC Intelligence (Shenzhen) Tech Co., Ltd., Shenzhen, China. 4National Centre for International Research on Photoelectric and Energy Materials, Yunnan University, Kunming, China. 5School of Mechanical Engineering, Beijing Institute of Technology, Beijing, China.</td>
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<td>1School of Automation Science and Electrical Engineering, Beihang University, 100191 Beijing, China. 2School of Mechanical Engineering and Automation, Beihang University, 100191 Beijing, China. 3Ningbo Institute of Materials Technology and Engineering, Chinese Academy of Sciences, 315201 Ningbo, China. 4School of Electrical Engineering and Automation, Anhui University, 230061 Anhui, China.</td>
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Ping Wang1, Longhao Yan1, Jingwei Liu2, Jun Wang3 and Yidui Lin4
1Institute for Transportation Systems Engineering Research (ITSER), School of Electric and Control Engineering, Chang'an University, Xi'an, China. 2School of Electric and Control Engineering, Chang'an University, Xi'an, China. 3Toll Collection Center for Shanxi Freeway Xi'an, China.

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Duona Zhang1, Wenerui Ding2, Hongyu Wang1 and Baochang Zhang3
1School of Electronics and Information Engineering, Beihang University, Beijing, China. 2Unmanned Systems, Research Institute Beihang University, Beijing, China. 3School of Automation Science and Electrical Engineering, Beihang University, Beijing, China.

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Hongyu Wang1, Wenerui Ding2, Duona Zhang1 and Baochang Zhang3
1School of Electronics and Information Engineering, Beihang University, Beijing, China. 2Unmanned Systems, Research Institute Beihang University, Beijing, China. 3School of Automation Science and Electrical Engineering, Beihang University, Beijing, China.

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Ziyang Liu1, Weibai Chen1, Jianhua Wang1, Xingming Wu1, Haosong Yue1, Zongju Peng2 and Zhenguang Li3
1School of Automation Science and Electrical Engineering, Beihang University, Beijing, 100191, China. 2Faculty of Electrical Engineering and Computer Science, Ningbo University, Ningbo, 315211, China. 3Institute for Infocomm Research, Singapore, 138632, Singapore.
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Institute of Electrical Engineering And Automation Harbin Institute of Technology Harbin, China

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Runqi Wang,1, Wei Wang,1, Teli Ma2 and Baochang Zhang3
1School of Automation Science and Electrical Engineering, Beihang University, Beijing, China. 2ShenYuan Honors College Beihang University, Beijing, China. 3School of Automation Science and Electrical Engineering, Beihang University, Shenzhen Academy of Aerospace Technology, China.

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Guoliang Zhang, Lin Ma, Jianjun Ge, De Zhang, Guanghong Liu and Fangpei Zhang
Information Science Academy, China Electronics technology, group corporation, Beijing, China.

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Lu Liu1, Xiaojun Song, Jingmeng Liu3, Weihai Chen1 and Guilin Yang2
1School of Automation Science and Electrical Engineering, Beihang University, Beijing 100191, China. 2Ningbo Institute of Materials Technology and Engineering, Chinese Academy of Sciences, Ningbo 315201, China.

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State Key Laboratory of Virtual Reality Technology and Systems, Beihang University, Beijing, 100191, China.

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Yang Li1, Weihai Chen1, Jianhua Wang1, Jiabin Zhang2 and Xiantao Sun3
1School of Automation Science and Electrical Engineering, Beihang University, Beijing 100191, China. 2School of Mechanical Engineering and Automation, Beihang University, Beijing, 100191, China. 3School of Electrical and Automation, Anhui University, Anhui, 230601, China.

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School of Aeronautical Science and Engineering, Beihang University, Beijing, China.

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Shuaiqiang Pu1, Dongying Ma3, Xiaoguang Hu2, Hui Wang1 and Zhenghan Li3
1Beijing Institute of Electronic System Engineering, Beijing, 100039, P R China. 2State Key Laboratory of Virtual Reality Technology and Systems, Beihang University Beijing, 100191, P R China.

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1Beijing Institute of Electronic System Engineering, Beijing, 100039, P R China. 2State Key Lab of Virtual Reality Technology and Systems, Beihang University Beijing, 100191, P R China. 3State Key Laboratory of Virtual, Reality Technology and Systems, Beihang University, Beijing, 100039, P R China. 4Beijing Electrical Engineering Institute Beijing, 100074, P R China.

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Yi Sun1, Xiaoguang Hu1, Jin Xiao3, Gaofeng Zhang3, Shaojie Wang4 and Lei Liu3
1State Key Laboratory of Virtual, Reality Technology and Systems, Beihang University, Beijing, 100191, P R China. 2Beijing Electrical Engineering Institute Beijing, 100074, P R China.
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1Nanjing University of Science and Technology Zijin College Nanjing, China. 2Nari Technology Development Limited Company Nanjing, China.

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Jing Dai1, Haoran Wang2, Yue Ni2, Haiyan Li3 and Shuo Shi4
1China Academy of Launch, Vehicle Technology, Beijing, China. 2School of Automation Science and Electrical Engineering, Beihang University, Beijing, China.

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Min Zhu1, Zhulong Bai1, Ao Liu1, Chunling Yang1 and Chaoyong Guo2
1School of Electrical Engineering and Automation, Harbin Institute of Technology, Harbin, China. 2Beijing Institute of Control Engineering, Beijing, China.

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Chao Luy1, Gang Wei1, Zhaoxiang Wen2, Hongying Zhang1, Qi Wu2 and Haitao Jing2
1School of Electrical Engineering and Automation, Harbin Institute of Technology, Harbin, China. 2Shanghai Institute of Satellite Engineering, Shanghai, China.

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Qiwang Weng1, Shaoqin Wang1 and Jian Shi1,2
1School of Automation Science and Electrical Engineering, Beihang University, Beijing 100191, China. 2Beijing Advanced Innovation Center for Big Data-Based Precision Medicine, Beihang University, Beijing 100191, China.

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1School of Electrical Engineering and Automation, Harbin Institute of Technology, Harbin, China. 2School of Electrical Engineering and Automation, Harbin Institute of Technology, Harbin, China. 3School of Electrical Engineering and Automation, Harbin Institute of Technology, Harbin, China. 4School of Electrical Engineering and Automation, Harbin Institute of Technology, Harbin, China. 5School of Electrical Engineering and Automation, Harbin Institute of Technology, Harbin, China. 6State Grid Heilongjiang Electric Power, T&F Engineering Co. Ltd, Harbin, China.

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School of Automation Science and Electrical Engineering, Beihang University, Beijing, China.

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Servo Engineering Center, Beijing Institute of Automatic Control, Equipment, Beijing, China.
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Ganggang Zhong1, Yanan Li2 and Jiangang Li3
1School of Mechanical Engineering and Automation, Harbin Institute of Technology, Shenzhen, China
2School of Engineering and Informatics, University of Sussex, Brighton, BN1 9RH, UK.

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Yurong Li1, Yi Qin1, Fujie Wang1, Fang Guo1 and John W. Yuen1
1School of Electrical Engineering & Intelligentization, Dongguan University of Technology, Dongguan, China
2School of Engineering and Informatics, University of Sussex, Brighton, BN1 9RH, UK.

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School of Automation Science and Electrical Engineering, Beihang University (BUAA), Beijing, China.

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Wei Luo and Lu Shen
Nanjing University of Science and Technology Zijin College, Nanjing, China.

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Jin Xiao1, Zhiwei Zhu1, Xiaoguang Hu1, Guofeng Zhang1 and Lei Liu2
1State Key Laboratory of Virtual Reality Technology and Systems, Beihang University, Beijing, 100191, P.R. China.
2Beijing Electro Mechanical Engineering Institute Beijing, 100074, P.R. China.

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1Research and Development Department, China Academy of Launch Vehicle Technology, Beijing, China.
2Beihang University, Beijing, China.

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1School of Automation Science and Electrical Engineering, Beihang University, Beijing, China.
2Science and Technology on Space Intelligent Control Laboratory, Beijing Institute of Control Engineering, Beijing, China.
3China Academy of Launch Vehicle Technology, Beijing, China.

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Haiyu Wang1, Shunfeng Yang1, Haiyu Chen2, Shun Liu1 and Hang Su1
1School of Electrical Engineering, Xi’an Jiaotong University, Xi’an, Shaanxi, China.
2School of Electrical Engineering, Southwest Jiaotong University, Chengdu, Sichuan, China.

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Maosen Tang1, Shen Jun1, Zhengdong Zhou2, Xinglai Ge3, Dong Liu3 and Rongbin Zhou1
1School of Electrical Engineering, Southwest Jiaotong University, Chengdu, Sichuan, China.
2School of Electrical Engineering, Xi’an Jiaotong University, Xi’an, Shaanxi, China.
3School of Electrical Engineering, Southwest Jiaotong University, Chengdu, Sichuan, China.

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Zhijie Liu1, Ke-Jun Li2, Xiaoyu Lai2, Jinju Wang3 and Shunfeng Yang4
1School of Electrical Engineering, Shandong University, Jinan, Shandong, China.
2School of Electrical Engineering, Shandong University, Jinan, Shandong, China.
3School of Electrical Engineering, Shandong University, Jinan, Shandong, China.
4School of Electrical Engineering, Nanyang Technological University, Singapore.
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<td>School of Automation Science and Electrical Engineering, Beihang University, Beijing, China.</td>
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Information Center Capital Medical University Beijing, China.

High-resolution Thermopile Array Sensor-based System for Human Detection and Tracking in Indoor Environment
Nanhao Gu, Bo Yang and Tianfu Li
School of Automation Science and Electrical Engineering, Beihang University, Beijing, China.

Design and Simulation of Large Flowrate Fuel Metering Valve of Aero engine Based on AMESim
Jie Hang, Yangyang Li, Liman Yang and Yunhua Li
1School of Automation Science and Electrical Engineering, Beihang University, Beijing 100191, China.
2Aero Engine Academy of China Beijing 101300, China.

Distributed Formation Control of Autonomous Underwater Vehicles Without Velocity Measurement
Yuwei Zhang, Shaoping Wang, and Xingjian Wang
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2Beijing Advanced Innovation Center for Big Data-Based Precision Medicine, Beihang University, Beijing 100191, China.

Session [SS23]: Invited Session on Grid-connected and isolated renewable energy systems

A Single-phase Voltage Source Inverter With Lower-Voltage-Rated Capacitor and Ripple Power Decoupling Function
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Abstracts
Air pollution is a contributor to approximately one in every nine deaths annually. To counteract health issues resulting from air pollution, air quality monitoring is being carried out extensively in urban environments. Currently, however, city air quality monitoring stations are expensive to maintain, resulting in sparse coverage. In this paper, we introduce the design and development of the MegaSense Cyber-Physical System (CPS) for spatially distributed IoT-based monitoring of urban air quality. MegaSense is able to produce aggregated, privacy-aware maps and history graphs of collected pollution data. It provides a feedback loop in the form of personal outdoor and indoor air pollution exposure information, allowing citizens to take measures to avoid future exposure. We present a battery-powered, portable low-cost air quality sensor design for sampling PM$_{2.5}$ and air pollutant gases in different micro-environments. We validate the approach with a use case in Helsinki, deploying MegaSense with citizens carrying low-maintenance portable sensors, and using smartphone exposure apps. We demonstrate daily air pollution exposure profiles and the air pollution hotspot profile of a district.

Our contributions have applications in policy intervention management mechanisms and design of clean air routing and healthier navigation applications to reduce pollution exposure.

Keywords: Air quality, Cyber-physical systems, Internet of things, Low-cost sensors, Data integration and visualization.
Robust principal component analysis (RPCA) via the nuclear norm minimization (NNM) is a powerful tool for image processing problems. However, most of NNM methods only consider the number of non-zero singular values of the observation matrix, and ignore the different proportions of data information in different singular values, which are related to the exact rank of clean data and should be treated differently. In this paper, we propose an adaptive weighted RPCA to simultaneously preserve low-rank structure and restore the corrupted parts. In our method, the sum of weighted singular values is included in the objective function of minimization, several novel topologies, constructed by LCM, are designed in detail. Finally, an experimental prototype is made to prove the correctness of the novel topology and control strategy.

Keywords: Topological derivation method, High frequency isolated, Multi-level inverter, Two power stage.

Adaptive Weighted Robust Principal Component Analysis
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A Temporal Forecasting Driven Approach Using Facebook’s Prophet Method for Anomaly Detection in Sewer Air Temperature Sensor System
Karthick Thyagarajan1,a, Sarath Kodagoda1,b, Nalika Ulapane1,c and Mukesh Prasad1,d
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Smart sensor systems play a decisive role in the condition assessment of concrete sewer pipes going through microbial corrosion. Few Australian water utilities adopt a predictive analytic model for estimating the corrosion. They require sensor inputs like sewer air temperature data for corrosion prediction. A sensor system was developed to monitor the daily variation of sewer air temperature inside the harsh sewer environmental conditions. However, a diagnostic tool to evaluate the streaming sensor data is vital for reliable monitoring. In this context, this paper proposes a temporal forecasting driven approach for anomaly detection in sewer air temperature sensor system. Several temporal forecasting models were comprehensively evaluated and adopted Facebook’s Prophet method based forecasting to develop an anomaly detection approach. The proposed approach was evaluated with sewer air temperature sensor data and the results indicate a reasonable anomaly detection performance.

Keywords: Anomaly detection, ARIMA, Bagged model, Concrete corrosion, ETS model, Facebook Prophet, Forecasting, Sewer pipe, TBATS model, Temperature sensor, Time series model.

Model Predictive Power Control with Current Stress Optimization for Bidirectional Series Resonant DCDC Converter
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Dual bridge series resonant converter (DBSRC) has attracted more attentions in power electronic transformer (PET) application. In this paper, a model predictive power control method with current stress optimization is proposed for dual bridge series resonant dc-dc converters (DBSRC) in power electronic transformer application, aiming at the optimization of operating efficiency and dynamic response capability. The current stress optimization model under triple phase shift control is analyzed and the operating efficiency is improved. At the same time, by introducing a virtual power component, the control method does not need...
a load current sensor, and can realize the model predictive power control of the DBSRC through the input and output voltage sensors, improving the dynamic response capability of the converter. Finally, through the combination of two optimization control methods, the model predictive power control method with current stress optimization is obtained, and a comparison with the traditional control method is carried out on a 250W experimental prototype. Experimental results show that this method can effectively reduce the current stress of the converter, improve the operating efficiency, and significantly improve the dynamic response capability of the converter.

Keywords: Power electronic transformer, Dual bridge series resonant DC-DC converters, Model predictive control, Current stress optimization, Dynamic response.

Session [TT01] T01: Industrial Informatics & Computational Intelligence (I)

P1071
Design of a Shared Platform for Interactive Public Art from Perspective of Dynamic Vision
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In order to improve the interaction and sharing of interactive public art, a design scheme of interactive public art sharing platform is proposed based on dynamic visual perspective. The interactive public art dynamic visual image acquisition model is constructed, the multi-dimensional feature extraction method is used to realize the optimal recognition of interactive public art visual image, and the cascade filtering method is used to reduce the noise of the public art dynamic visual image. The filter can output the minimum energy under the condition of satisfying the constraint. The public art dynamic visual image will be processed by block segmentation, and the feature detection model of the public art visual image will be constructed, and the basic edge feature segmentation theory will be established. The contour curve segmentation constraint equation of interactive public art dynamic visual image is obtained, and the spatial information, visual structure and information feature of interactive public art dynamic visual image are extracted. The interactive public art dynamic visual image feature recognition is realized. The software design of the interactive public art sharing platform is carried out in the embedded environment, and the interface design and database loading of the interactive public art sharing platform are carried out in the embedded Open Core kernel. The simulation results show that the public art sharing platform has better visual expression ability, better man-machine interaction, and public art sharing level and interaction level are improved.

Keywords: Dynamic vision, Interactive, Public art, Shared platform, Image, Software design.

P1013
Summary of Pedestrian Traffic Statistics Research
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As an important research direction in the field of computer vision and intelligent security, pedestrian traffic statistics have received more and more attention from the industry. This paper reviews the research on the important aspects of pedestrian flow statistics technology: feature extraction, target detection and pedestrian counting. Firstly, the typical methods of feature extraction are classified and compared according to the characteristics, and then the research on target detection and recognition is carried out. After summarizing, the pedestrian target count is introduced from the traditional method and the deep learning method respectively, and finally the future development is expected.

Keywords: Pedestrian flow statistics, Feature extraction, Target detection and recognition, Target count.

P1544
Multiple Screen Control Application with Facial and Gesture Recognitions in a Manufacturing Control Room
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In the age of Industry 4.0, the operators in a manufacturing control room require to work with digital content such as factory KPI dashboards, live dashboards and controls on multiple displays. Manipulating and arranging the displays and their layout with a user’s face and hand gesture could be more natural, automatic and interactive for the control room operators. Therefore, a display control framework is developed in the Manufacturing Intelligence Control Room (MICR) at the Advanced Remanufacturing and Technology Centre (ARTC), using the open-source FaceNet facial recognition and OpenPose hand feature recognition algorithms and integrating with the display control system.
ICIEA 2020 — Abstracts

Design of a Novel Device for Measuring the Inertia of Helmet
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The moment of inertia is an important factor affecting the comfort of the helmet. However, the shape of the helmet has irregular characteristics, so the moment of inertia (MI) is difficult to measure. Therefore, this paper develops a device that accurately measures the MI of the helmet. The device uses the weighing method and the torsion method combined with the lever theory to measure the MI of the irregular helmet. Visual C++ is used as the development environment to create visualization software, which can display and print data. The device can accurately measure the center of gravity and moment of inertia of the helmet without damaging the helmet. It is a new method of measuring MI, and it is simple and reliable.

Keywords: Moment of Inertia (MI), Comfortable, Theory of leverage, Torsion.

Int-Papercut: An Intelligent Pattern Generation with Papercut Style Based on Convolutional Neural Network
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Paper cutting is a traditional folk art, as a world intangible cultural heritage (ICH), it expresses people’s social life and folk activities. However, papercut production still relies on rich pattern creation experience and fixed pattern, which limits the creation of paper-cut art, especially for novices. To address this gap, we put forward Int-Papercut, a new papercut pattern generation system based on convolutional neural network (CNN), which can recognize and mark the patterns of the input photos, and use the basic symbols of papercut to match and fill in, and finally convert the photos into clip-cut style patterns. Empirical qualitative data from two papercut experts and 8 papercut novices show Int-Papercut facilitated their understanding of paper cutting and production. Our system is expected to support users to freely create papercut works with their favorite pictures, and promote the protection, development and application of papercut culture.

Keywords: Papercut, Pattern generation, CNN, Intangible cultural heritage, Digital preservation.

Non-live Sessions

Session [TT02] TT02: Industrial Informatics & Computational Intelligence (II)

P1036

Improve Performances of a Laser Tracking System by Adopting a Modified Fuzzy Neural Network Controller
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In this study, a modified fuzzy neural network controller (MFNNC) is proposed to improve the control performance and tracking accuracy of a controller used in a laser tracking system (LTS). In a LTS, the objective of the controller is not only to track a moving target installed on the end-effector of a robot through adjustment of joint angles and velocities of a two Degrees-Of-Freedom (DOF) tracking gimbal that is composed of two DC motors, but also to obtain the smallest tracking errors with high tracking speed. For those purposes, different control strategies, including artificial intelligence controllers, are selected and studied. Two popular controllers, fuzzy logic and neural network controllers, are discussed and analyzed. As a result, a modified fuzzy neural network controller is designed and studied to try to improve and the control performance of the LTS. The simulation study results show that a better dynamic performance can be obtained by using the proposed modified fuzzy neural network controller.

Keywords: Modified fuzzy neural network controller, Laser tracking systems, Tracking gimbals, Dynamic tracking performances.

P103

Device Target Checking for Power Patrol Robot Based on Objectness Estimation
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In order to free people from daily patrol tasks in power substations, patrol robots are designed to check power
equipment status and read various electric meters. According to the requirements of patrol tasks, a hierarchical, coarse-to-fine, fast device detection and recognition method is proposed. The coarse detection is based on objectness, using \(8 \times 8\) Binarized Normed Gradients (BING) feature to generate proposals and filtering them using Support Vector Machine (SVM) trained by Local Binary Pattern (LBP) feature combining with histogram matching. The fine detection utilizes the color and contour feature of the basic elements of a certain device to obtain the status information or meter data. In this paper, instances of the device status checking and the pointer meter data reading are developed. The experiments validate the effectiveness, accuracy and real-time of this method.

**Keywords:** Patrol robot, Visual system, Objectness estimation, Device status checking, Meter data reading.

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P1027

A Review of Intelligent Methods for Unpaved Roads Condition Assessment

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Conventional road condition evaluation is an expensive and time-consuming task. Therefore data collection from indirect economical methods is desired by road monitoring agencies. Recently intelligent road condition monitoring has become popular. More studies have focused on automated paved road condition monitoring, and minimal research is available to date on automating gravel road condition assessment. Road roughness information gives an overall picture of the road but does not help in identifying the type of defect; therefore, it cannot be helpful in the more specific road maintenance plan. Road monitoring can be automated using data from conventional sensors, vehicles’ onboard devices, and audio and video streams from cost-effective devices. This paper reviews classical and intelligent methods for road condition evaluation in general and, more specifically, reviews studies proposing automated solutions targeting gravel or unpaved roads.

**Keywords:** Unpaved roads, Machine learning, Road condition monitoring, Data quality, Sensors.

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P1015

Summary of Scene Text Detection and Recognition

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In recent years, scene text recognition has received much attention, and has a wealth of application scenarios, such as: photo translation, image retrieval, scene understanding and so on. However, the text in the scene is also faced with many problems, such as: light changes, deformation text, text-string recognition under background noise interference, text skew and degree of curvature, and a large number of artistic fonts. Solving the above problems will always be a challenging thing. This paper reviews some recent work on text detection, text recognition and end-to-end text detection and recognition, and finally looks forward to the future development direction.

**Keywords:** Scene text recognition, Text detection, Text recognition, End-to-end.

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P1020

A Survey of Facial Expression Recognition Based on Deep Learning

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Facial expression recognition is the key research direction in many fields such as machine vision, pattern recognition and artificial intelligence. It has become a research hotspot of many scholars and experts. This paper gives a comprehensive overview of deep expression recognition from image preprocessing, common expression recognition networks, and common expression databases. Then we review the current design and training strategies of deep neural networks based on static images and dynamic images, and discuss their advantages and limitations. Finally, the future challenges and corresponding opportunities in the field are analyzed, as well as the future direction of deep learning expression recognition systems.

**Keywords:** Facial expression recognition, Pre-processing, Deep neural network.
Fault Diagnosis of Subway Plug Door Based on KPCA, LSSVM, SVM, GWO

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Fault diagnosis of the subway plug door is an indispensable part of ensuring the safe operation of the city subway system. Taking the developed digital signal processing technology into consideration, a novel fault diagnosis method for subway plug doors based on Kernel Principal Component Analysis (KPCA) and Least Squares Support Vector Machine (LSSVM) optimized by Cuckoo Search (CS) is proposed. First, fault features are extracted from the original data, and then the dimension of features is reduced by KPCA. Later, CS-LSSVM is used as the classification model for subway plug door faults. Experimental results indicate that the diagnosis model can quickly and accurately identify different fault status. In addition, CS provides faster convergence speed than Genetic Algorithms (GA) and Particle Swarm Optimization (PSO), and CS-LSSVM has higher accuracy in fault diagnosis than BP Neural Network and traditional Support Vector Machine.

Keywords: Subway plug door, Fault diagnosis, LSSVM, CS, KPCA.

P1459

Fault Diagnosis of Subway Plug Door Based on Isomap and GWO-SVM

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In order to solve the problem of high false alarm and missing alarm rate in health fault diagnosis of subway plug door, this paper proposes a health fault diagnosis model of subway plug door based on Isomap and GWO (grey Wolf swarm optimization support vector machine (SVM)). According to the nonlinear and non-stationary characteristics of the current curve of the subway plug door motor, the model constructs multi-feature parameters, Uses Isomap dimension reduction optimization, and inputs the feature set after dimension reduction into the support vector machine based on gray Wolf swarm optimization for training. Finally, in the experiment, the plug door experiments have been carried out to verify the measured data, the results show that support vector machine (SVM) based on gray Wolf group algorithm optimization diagnosis model than directly using the BP neural network or support vector machine (SVM) diagnosis model has higher precision of fault diagnosis, relative experimental error smaller and has certain actual application value.

Keywords: Subway plug door, Fault diagnosis, SVM, GWO, Isomap.
between the inner window and the background window. Based on this concept, a new hyperspectral image anomaly detection framework is constructed, which is composed of (1) anomaly detection layer, (2) background suppression layer, and (3) criteria layer. Experimental results show that compared with the traditional two-window models (i.e., global RX, local RX and KRX), this method makes full use of both the local spatial structure information and the spectral dimension information, adaptively inhibits the background, reduces the false alarm rate, and improves the detection effect of abnormal targets with fewer pixels.

**Keywords:** Hyperspectral image, Anomaly detection, Spatial, Spectral, Background suppression, Multilayer structure.

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**P1273**

**Parameter Design and Performance Analysis of an Improved MOCEO Algorithm**

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In order to solve the multi-objective optimization problem, this paper proposes a multi-objective cross-entropy optimization (MOCEO) algorithm based on the original single-objective cross-entropy (CE) optimization algorithm. Situations, with a low probability for optimal point, and also, locations with a high probability to fall into local optimum after tested with standard test function ZDT4 and ZDT6 problems. The algorithm is then introduced an improved method called disturbance, including recombination, variance disturbance and varying population size. Each operation contains a variable parameter. Appropriate selection of parameters can maximize the optimization ability. A set of optimal parameters is designed and the answers are verified by a comparative study with other metaheuristic optimization algorithms such as NSGA-II, SPEA2, MOEA/D and PAES in similar conditions. The results indicate that those improvements are effective and the algorithm proposed in this paper is superior to other algorithms. It has the advantages of strong searching ability and high robustness which is applicable to challenging difficulties with unknown search spaces.

**Keywords:** Cross-Entropy algorithm, Evolutionary algorithm, Multi-objective optimization, Parameter design.

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**P1185**

**Improved RCM Method by AHP-FCE for the Maintenance Strategy of Reciprocating Compressor Unit**

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The iterative fuzzy comprehensive evaluation model of extension analytic hierarchy process (AHP-FCE) is applied to the evaluation of equipment importance. The scoring factors in the judgment matrix are quantified and the reliability of each element is increased. The results are introduced into the reliability-centered inspection and maintenance strategy (RCM), and put forward the preventive countermeasures of the main fault consequences, optimize the inspection and maintenance program. Firstly, the evaluation objective is established and the subsystem of the unit is divided. Secondly, the AHP-FCE method is applied to improve the traditional importance evaluation method, and the weight calculation of random sampling is carried out to determine the functional significant item (FSI). Then, failure mode and effects analysis (FMEA) is carried out to determine the risk level and fault impact. After that, the least square method is used to fit the fault time point of numerical simulation. By using Weibull distribution model to solve the life model of compressor parts and piston rings. The result shows that the improved method is feasible, and gives some guidance for the design, manufacture, production and maintenance of reciprocating compressor from a more fair and objective point of view.

**Keywords:** Compressor unit, RCM, Maintenance strategy, AHP-FCE, Mathematical statistics.
Non-live Sessions

P1510
Managing SLA Violation in the cloud using Fuzzy re-SchdNeg Decision Model
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The rapid increase in the number of consumers and a dynamic change like cloud computing causes different challenges for the service providers to fulfill the service level agreement (SLA). When the SLA violation occurs, the SaaS providers not only to pay the agreed penalty in terms of money, but the trusted relationship may affect that impact on lose of current or potential customers. Therefore, the interacting parties need a proactive SLA management system that alerts beforehand the service provider when it detects any expected violation and provides an optimal decision system to regulate and scale available resources to avoid service violation. Most of the existing studies focused on predicting SLA violation to avoid SLA violation, however, they have ignored considering the process of rescheduling and renegotiation while dealing with service violation that plays a vital role to prevent service violation.

In this paper, we propose a fuzzy rescheduling/ renegotiation (re-SchdNeg) decision support system that offers the best alternative solution for SaaS providers to apply rescheduling techniques to allocate potential violated jobs on available resources. When the system finds the available services are insufficient to handle the possible violated job, the system will start a renegotiation session.

Keywords: SLA violation prediction, Cloud computing, SLA monitoring, Rescheduling, Negotiation, Renegotiation, Resource management.

P1568
A Densely Connected Face Super-Resolution Network Based on Attention Mechanism
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Super resolution reconstruction of human face is a cost effective way to obtain high resolution images from its corresponding low resolution face. It is also known as face illusion. In order to obtain clearer texture details, this paper proposes a densely connected super-resolution algorithm based on attention mechanism which consists of feature extraction and image reconstruction. By integrating channel and spatial domain information of the feature map, the Multi Attention Domain Module (MADM) is proposed: Features are weighted and recombined by analyzing the relationship between channels and spatial information of feature maps. The features of different layers are fused using dense connections. Experimental results show that the proposed algorithm can improve by up to 0.5dB in PSNR and the reconstructed face image has clearer texture details compared to existing algorithms.

Keywords: Attention mechanism, Dense connection, Face super-resolution, Feature fusion, Neural network.

P1038
Anomaly Detection of Heat Energy Usage in District Heating Substations Using LSTM based Variational Autoencoder Combined with Physical Model
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District heating systems that distribute heat through pipelines to residential and commercial buildings have been widely used in Northern Europe. The energy efficiency of

P1166
Fault-Tolerant Application Mapping on to ZMesh Topology based Network-on-Chip Design
P Veda Bhanu1,3, Nikita Mandapati1,3, Soumya J1,2 and Linga Reddy Cenkeramaddi2
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This paper proposes Particle Swarm Optimization (PSO) based fault-tolerant application mapping on to ZMesh topology based Network-on-Chip (NoC) design. Permanent faults in application cores has been considered and performed application mapping using PSO. The major contribution of this paper is to find out the best position for the spare core to be placed in the network using PSO. Experiments have been carried out by scaling the ZMesh network size and percentage of network faults. The results show that the proposed approach leads to minimum overhead in communication cost over fault-free result.

Keywords: Network-on-Chip, ZMesh, Fault tolerance, Spare core, Application mapping, Particle swarm optimization.
district heating systems is of great interest to energy stakeholders. However, it is not uncommon that district heating systems fail to achieve the expected performance due to various faults. Identification of such rare observations that are different significantly from the majority of the meter readings data plays a vital role in system diagnosis. In this study, a new hybrid approach is proposed for anomaly detection of a district heating substation, which consists of a simplified physical model and a Long Short Term Memory based Variational Autoencoder (LSTM VAE). A dataset of an anonymous substation in Sweden is used as a case study. The performance of two state of art models, LSTM and long short term memory based autoencoder (LSTM AE) are evaluated and compared with the LSTM VAE. Experimental results show that LSTM VAE outperforms the baseline models in terms of Area under receiver operating characteristic (ROC) curve (AUC) and F1 score when an optimal threshold is applied.

**Keywords:** Energy system, Neural networks, Anomaly detection, Computational intelligence, Machine learning.

**A Review on Data Analysis of Bitcoin Transaction Entity**

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\(^4\), \(^5\)ICIEA 2020 — Abstracts

Bitcoin is a decentralized cryptocurrency that has led to a new trading model. It allows people to trade directly without going through financial institutions such as banks. This model results in many transactions that occur outside the law and beyond ethical constraints. In such an anonymous environment, the large number of entities using Bitcoins, and the huge scale of the Bitcoin trading network make it difficult for users to have a rough idea of the entire trading network before transaction. Thus, it is of great theoretical and practical significance to summarize the research problems, achievements and possible research trends based on Bitcoin data analysis. Therefore, in this paper we review the literatures about data analysis on Bitcoin transaction entities. Starting from the relevant conceptual framework of Bitcoin, this paper divides the existing research models into three categories, heuristic algorithm identification of entities, transaction descriptive statistics and network analysis, and visual system analysis. By analyzing the transaction entity, Bitcoin transaction data can be processed in a manner which is similar to an account, such as a bank or credit card, thereby achieving the purpose of in-depth analysis of all transaction activities related to the account entity. Finally, we summarize the data analysis results of Bitcoin transaction network and prospects of the future research directions.

**Keywords:** Blockchain, Bitcoin, Cryptocurrency, Transaction entity, Data analysis.

**The Effect of Hatch Angles on the Microstructure and Mechanical Properties of Selective Laser Melting 316L Stainless Steel**

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In this paper, the effects of hatch angles on the microstructure and mechanical properties of 316L stainless steel parts fabricated by selective laser melting are studied. In order to further observe the evolution of microstructures and textures, optical microscope (OM), scanning electron microscope (SEM), and electron backscatter diffraction (EBSD) techniques are used to characterize the samples. Finally, TUKON 2100 measuring machine is used to test the Vickers microhardness of different surfaces. The results show the effect of hatch angles on the length and width of the molten pool is not much different. Compared with 0°, the grain still retains the \(<011>\) orientation distribution along the building direction (Z-axis), while the \(<011>\) orientation feature is more weakened along the direction (X-axis) when the hatch angle is 67°. The hatch angles have a tiny influence on hardness.

**Keywords:** Selective laser melting, Microstructure, Mechanical properties.

**A Periodic Event-Triggering Reactive Power Sharing Control in an Islanded Microgrid considering DoS Attacks**

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This paper addresses the reactive power sharing problem of the microgrid under DoS (Denial-of-Service) attacks. An accurate reactive power sharing based on a periodic event-triggered update method is proposed, which can reduce some communication burden and avoid the Zeno phenomenon. Considering that attackers may launch DoS attacks on the MG, the tolerance of DoS attacks of the reactive power control system is studied. We find that the tolerance range of DoS frequency and duration for the DG is related to the smallest event-interval time of the event-triggered update method. The relative simulation results are given in the final of this paper.

**Keywords:** Microgrids, Cyber-Physical system, Event-triggered mechanism, DoS attack, Consensus controller.
Nowadays multi-source data can be collected and monitored from intelligent distribution room, but the other side of automation is that, large number of intelligent distribution rooms are unattended operation, and the lack of health status evaluation brings hidden dangers to personal and property safety. It is of great economic and social value to study the health status evaluation method of intelligent distribution rooms. Based on the equipment importance theory and health index theory, this paper establishes a comprehensive evaluation index system of intelligent distribution room from four aspects: primary equipment health index, secondary equipment health index, environmental security health index and power-supply reliability index. In order to overcome the subjective problem of simple analytic hierarchy process (AHP), this paper introduces AHP-entropy method to allocate the weight of each index of intelligent distribution room. The health status assessment method of intelligent distribution room based on AHP-entropy weight method is proposed for the first time. Finally, an example of two distribution rooms in Guangzhou is given to verify the feasibility of the method proposed in this paper.

**Keywords:** Intelligent distribution room, Analytic hierarchy process, Entropy weight method, Health status assessment.

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**P1193**

**An Indoor Positioning Approach Using Smartphone Based on PDR and EKF**

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Recently, Pedestrian Dead Reckoning (PDR) based methods, which perform mobile continuous indoor positioning, have obtained remarkable performance. However, the precision of the hardware commonly used is pretty low, many existing methods may produce large errors. In this paper, we propose a novel method, which uses low power Bluetooth Beacon as auxiliary sensor, to improve positioning accuracy and reduce Bluetooth deployment costs. To get more accurate steps, we use a filtering window to filter the acceleration feature. Then, we introduce an Extended Kalman Filter (EKF) method to correct PDR navigation. Furthermore, we reduce the number of Bluetooth Beacon by using a Cooperation-Proximity method. The experimental results show that the filtering method proposed in this paper can filter out invalid acceleration feature, so as to accurately measure the number of steps. In terms of the fitting degree between the walking track and the set route, the proposed method is 2.5% - 12% higher than the traditional methods, which reflects the improvement on positioning accuracy.

**Keywords:** Indoor positioning, Pedestrian dead reckoning, Bluetooth beacon, Extended kalman filter.

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**P1513**

**Research on RLGA-based Hardware Evolution Optimization Technology**

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This paper discusses, comparing with the most commonly used genetic algorithms, how to obtain RLGA via researches on reinforcement learning and improves on genetic algorithms, so as to meet our requirements for hardware evolutionary operations, under the structure of the hard core microprocessor plus FPGA and the reconfigurable evolution circuit structure based on dynamic reconfiguration technology.

**Keywords:** Evolutionary hardware, Reinforcement learning, Styling, Evolutionary algorithms.
ICIEA 2020 — Abstracts

P1595

Numerical Modeling of the Effects of Electrode Spacing and Multilayered Concrete Resistivity on the Apparent Resistivity Measured Using Wenner Method
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Smart Sensing technologies can play an important role in the conditional assessment of concrete sewer pipe linings. In the long-term, the permeation of acids can deteriorate the pipe linings. Currently, there are no proven sensors available to non-invasively estimate the depth of acid permeation in real-time. The electrical resistivity measurement on the surface of the linings can indicate the sub-surface acid moisture conditions. In this study, we consider acid permeated linings as a two resistivity layer concrete sample, where the top resistivity layer is assumed to be acid permeated and the bottom resistivity layer indicates normal moisture conditions. Firstly, we modeled the sensor based on the four-probe Wenner method. The measurements of the developed model were compared with the previous studies for validation. Then, the sensor model was utilized to study the effects of electrode contact area, electrode spacing distance and two resistivity layered concrete on the apparent resistivity measurements. All the simulations were carried out by varying the thickness of top resistivity layer concrete. The simulation study indicated that the electrode contact area has very minimal effects on apparent resistivity measurements. Also, an increase in apparent resistivity measurements was observed when there is an increase in the distance of the electrode spacing. Further, a machine learning approach using Gaussian process regression modeling was formulated to estimate the depth of acid permeated layer.

Keywords: Apparent resistivity, Acid permeation, Concrete, Corrosion, Electrode spacing, Electrical resistivity, Four probe, Gaussian process, Multilayered concrete resistivity, Numerical modeling, Pipe linings, Sensor, Sewer, Wenner method.

Session [TT06] T06: Cyber-physical Systems (I)

P1633

Image Encryption Based on Fractional-Order Chen Hyperchaotic System
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This paper proposes a novel image encryption algorithm with the encrypted sequence encoded based on a fractional-order hyperchaotic Chen system. Specifically, a set of system parameters is firstly generated using an 8-byte secret key. Then we create the encrypted sequence by mixing the system parameters with the hyperchaos sequence generated by the fractional-order Chen system. In the end, the encryption sequence is XOR with the image plaintext to produce the encrypted image. In order to increase the ability to resist attack, the ciphertext of the previous pixel is employed for the encryption of subsequent pixels. Numerical experiments have demonstrated the cryptographic excel-
The reconnaissance or electronic warfare payload UAV swarm networking and coordination functions are highly autonomous swarm intelligent Cyber-Physical System (CPS). The system core of continuous and effective operation lies in the cooperative work between intelligent entities. In the process of operation, the external interference / Iut of the system or the degradation / abnormality of the internal nodes will affect the security, efficiency and reliability of the system. In this paper, the idea of evolutionary game is used to dynamically reconstruct the resources of the degenerating swarm, reconfigure the available resources, to make the swarm reaching an evolutionary stable state in a certain period of time, so as to improve the overall utilization rate of the cluster resources the flexibility of the swarm and the overall performance of the swarm from the system level, and ensuring continually and effectively safe operation of the swarm system.

Keywords: Swarm, Resource, Evolutionary game, Dynamic reconstruction.

P1309
Low-Cost Air Quality Sensing Process: Validation by Indoor-Outdoor Measurements
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Air pollution is a main challenge in societies with particular matter PM$_{2.5}$ as the major air pollutant causing serious health implications. Due to health and economic impacts of air pollution, low-cost and portable air quality sensors can be vastly deployed to gain personal air pollutant exposure. In this paper, we present an air quality sensing process needed for low-cost sensors which are planned for long-term use. The steps of this process include design and production, laboratory tests, field tests, deployment, and maintenance. As a case study, we focus on the field test, where we use two generations of a portable air quality sensor (capable of measuring meteorological variables and PM$_{2.5}$) to perform an indoor-outdoor measurement. The study found that all of the measurements shown to be consistent through validation among themselves. The sensors accuracy also demonstrate to be adequate by showing similar readings compared to the nearest air quality reference station.

Keywords: Air quality, Indoor air quality, Outdoor air quality, Low-cost sensors, Sensor validation.

P1019
Path Planning System for Smart Cars Used in Education
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In this paper, we developed a path planning system for smart cars for teaching electronic engineering or computer science, which consists of the interactive platform for smart cars development and path planning. Designed by Visual C++, the interactive platform can call Matlab engine, allows users to choose path optimization algorithms such as genetic or A-star(A*) algorithm for different tasks and control smart cars through serial ports. The simulation and practice demonstrate that our interactive platform can help learners to plan paths and control intelligent vehicles without specially designing a user interface.

Keywords: Path planning, STEAM, Smart cars, Genetic Algorithm, A-star(A*) algorithm.
Session [TT07] TT07: Control and Systems (I)

P1026
Improving Sustainability in the Value Chain of the Apparel Industry Empowered with Social Manufacturing
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One of the major contributions of social manufacturing is in the realm of sustainability. The apparel industry is a good example to assess contribution of social manufacturing to improve sustainability in practice. Value chains in the apparel industry are faced with various challenges regarding sustainability issues. Apparel companies pay higher attention to economic sustainability issues, and environmental and social sustainability issues of the apparel industry are often underrated. We realize that the apparel brand owners have the highest impact on improving the sustainability of the apparel industry. Thus, we design a collaborative business model empowered with social manufacturing to join the forces among the brand owners for improving sustainability of the apparel industry throughout the value chain.

Keywords: Apparel industry, Digital textile printing, Joining forces, Social manufacturing, Sustainability.

P1027
Boundary Learning for Spark-Ignition Engine Control
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In gasoline engines, operating conditions are often pushed to the boundary between the knock and the nonknock regions to increase power output and fuel economy. Operating beyond the boundary causes high knock probabilities that can damage the engine. In the contrary, operating far below the boundary leads to low combustion efficiency. A boundary must be identified to avoid engine damage as well as to increase fuel economy. However, the stochasticity of the knock events makes the boundary identification difficult. In this work, a stochastic boundary estimation method based on the beta distribution and the Bayes method is proposed. The knock probability of an engine operating point is represented by a beta distribution. The Bayes estimation method is used for knock probability update and estimation, and information of the knock events among operating points is shared by a kernel function. The proposed method is validated on a full-scale engine test bench with a production engine.

Keywords: Gasoline engine, Knock, Boundary, Bayes, Beta distribution, Likelihood ratio.

P1216
Inertia Estimation for PMSM Drive System Using Artificial Neural Network
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The model reference adaptive method (MRAM) has been widely used in the inertia estimation of the permanent magnet synchronous motor (PMSM) drive system. In this method, the deviation between the reference model and the estimation model is inevitable, which is the fundamental inducement for the estimation error. To this end, this work proposes an improved MRAM, which adopts a changing gain factor (GF) to reduce this deviation so as to enhance the inertia estimation accuracy. To provide the changing GF, this paper develops a single-neuron-based artificial neural network (ANN). It utilizes the deviation as to enhance the inertia estimation accuracy. To provide the changing GF, this paper develops a single-neuron-based artificial neural network (ANN). It utilizes the deviation to adjust the GF dynamically. Furthermore, based on the instantaneous error-energy function, the proportional factor of the neuron is updated adaptively to force the estimated inertia to achieve a better tradeoff between stability and convergence rate. By simulations and real-time experiments implemented on the PMSM drive system under different working conditions, the effectiveness of the proposed methods is verified.

Keywords: Inertia estimation, Artificial neural network, Model reference adaptive method, Permanent magnet synchronous motor.
Adaptive Robust Control of the Cable Driven System for Position Tracking
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In this paper, an actuation redundancy system is presented based on wire rope driven, which can achieve high precision and fast response by the use of flexible cables instead of rigid links. However, due to the unilateral force of the cable and parameters uncertainty in the system, control of this flexible system is more challenging. To deal with such situation, an adaptive robust control method based on cable pre-tension is proposed, in which the pre-tension is employed to prevent cable slack, and the adaptive rate is designed to estimate the unknown parameters. Thanks to the model compensation and robust terms in the control law, the system is stable in closed loop and ensures that the errors of tracking and estimation converge to zero theoretically. Result of simulation shows that the robust adaptive controller performs better than the PID and feedforward controller. The characteristics of dynamic and accuracy are both improved.

Keywords: Cable driven system, Adaptive robust control, Position tracking, Tension distribution.

DFIG Pitch Angle Control with PID-type Fuzzy Logic Controller in a Microgrid
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The doubly fed induction generator (DFIG) is widely preferred in wind power technology. DFIG has the dynamic capability of coordinating the pitch angle of turbine blades and limiting DFIG power output. This paper presents a PID-type fuzzy logic controller (PID-type FLC) approach for the robust regulation of DFIG power based wind turbine at variable wind speed. The PID-type FLC is employed to enhance rotor speed and active power regulation of DFIG. Matlab/Simulink software based real-time simulations are performed for observing the relative performances of the proposed PID-type FLC for PAC as compared to the conventional proportional pitch control combined with proportional-integral pitch compensation. The simulation results substantiate the improvements in DFIG performance with the proposed control scheme at different operating conditions.

Keywords: Pitch angle control, FLC, Microgrid.

Online Optimal Control for Nonlinear Fin Stabilizer System of Marine Vessels via Time-based ADP Algorithm
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An online optimal control for fin stabilizer system of vessels based on adaptive dynamic programming (ADP) with an unknown system dynamic is developed in this paper. A model network is firstly used to identify the unknown fin stabilizer system dynamic and the optimal control can be obtained by using recorded and current data without knowledge of system dynamic. Then, two neural networks (NN) which are action and critic network are used to approximate the optimal control policy and optimal cost function respectively, two NNs are trained by using current and recorded data of the system and update processing is given for them once at sampling time. The proposed optimal control law can reduce roll motion of vessels at desired value and guarantee all states of the system, control signals and cost function are uniformly ultimately bounded (UUB) with desired bounded error. Simulation results are given to validate the effectiveness and performance of the proposed optimal control policy.

Keywords: Fin stabilizer, Adaptive dynamic programming, Optimal control, Unknown nonlinear system.
is proposed, both linear segments and circular arcs are treated as straight lines in motion layer under permitted tolerance. One major barrier of trajectory planning on G01 segments is the transition velocity at corner. In the requirement of high speed and high accuracy, a symmetrical corner transition method is studied, with the characteristics of simplicity and computing efficiency, promotes velocity at corner. Furthermore, a look-ahead method is applied to foresee the following path and road corner velocity. Based on real-time period routine, trapezoidal velocity profile is used for trajectory generation. The circle discrete method is integrated in interpreter software, the symmetrical corner transition method and intelligent look-ahead algorithm are integrated in motion control module. These software modules are separately tested and integrated together. Simulation results and practical experiments verified the effectiveness of the proposed method.

**Keywords:** Trajectory planning, Symmetrical corner transition, Interpreter, Lookahead, Interpolation, CNC.

**Session [TT08]**

**TT08: Control and Systems (II)**

**P1232**

**Online Maximum Power Factor Searching Control for Synchronous Reluctance Motor Based on Current Angle Control**

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To develop a high-efficiency synchronous reluctance motor (SynRM) drive system, a novel maximum power factor control (MPFC), which is based on current angle control with stator flux and stator resistance estimators, is proposed in this study. First, a conventional maximum power factor control (CMPPC) system using a saliency ratio of the SynRM to generate a fixed current angle command is introduced. Since the saliency ratio needs offline preprocessing and can’t be adjusted automatically, it is difficult to improve the performance of the MPFC in different operating region owing to the increasing of manufacturing cost and time-consuming. Therefore, an online maximum power factor searching control (MPFSC) based on current angle control is designed for the speed control of a SynRM. Moreover, a proportional-integral (PI) speed controller is adopted to generate the stator current command, and the proposed online MPFSC is employed to produce the current angle command. Finally, from the experimental results, the current angles of the optimal power factor (PF) can be effectively obtained online at different speed and load torque conditions.

**Keywords:** Synchronous Reluctance Motor (SynRM), Maximum Power Factor Searching Control (MPFSC), Flux estimator, Current angle control, Power Factor (PF).

**P1274**

**An Efficient Feedrate Dynamic Planning Method in CNC System**

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In this paper, a real-time feedrate dynamic planning method in CNC system is studied. Machine feedrate is affected by interference conditions from external environment. Commonly used machining modes such as Exact Stop Mode and Continuous Mode are both influenced by emergency stop, feedrate reset and feedrate override signals. The corresponding dynamic planning method is studied in this paper. Segment linking method is applied in Continuous Mode, guarantees constant velocity while traversing multi-blocks, and ensure acceleration within limits. In Exact Stop Mode, inference signals only affect the current segment. In Continuous Mode, always not only the current velocity profile is alternated, but also the successor blocks are affected. The proposed method response in time, the current interpolation period recalculation time parameter when influence signal comes and starts to response in action. The controller changes its logic as soon as interference signal comes and adjusts trajectory planning profile in real-time. The proposed method acts before interpolation, in Cartesian space. Experimental results show the effectiveness of the proposed dynamic planning method.

**Keywords:** Trajectory planning, Dynamic method, Feedrate override, Emergency stop, Feedrate reset, Motion control, CNC.

**P1331**

**Performances Assessment of Five-Phase Vienna Rectifier – PMSG SET: Experimental Validation of DC Bus Voltage Control**

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This paper investigates the DC voltage control of the 5-phase Vienna rectifier – PMSG non sinusoidal EMF. The model of the 5-phase Vienna rectifier and of 5-phase PMSG under normal operation are presented. A double closed control loops strategy with a current inner loop and a voltage extern loop is investigated. Experimental results highlight the DC voltage control loop.

**Keywords:** 5-phase Vienna rectifier, 5-phase PMSG, DC voltage control, Robust control.
This paper proposes a Fault Tolerant Control (FTC) scheme for a 2-DoF robotic system. The design is based on a new integral non-singular terminal sliding mode control (INTSMC) framework and aims at mitigating actuator faults whilst guaranteeing finite time convergence of the states.

The INTSMC-based FTC approach was shown to guarantee system stability and ensure good tracking performance under various faulty conditions.

Keywords: Fault-tolerant control, Integral non-singular terminal sliding mode control, Lyapunov stability criteria, Robotic manipulator.

Drilling operations for geothermal and hydrocarbon energy involves technology that controls a highly dynamic and complex process. A transition from assisted control to a higher level of automation not only requires a step-change in technology but also in infrastructure for development and validation of these technologies. The lack of realistic and scalable test environments for automated drilling systems delays qualification of new technology and limits the potential for the industry to reduce costs and minimize the carbon footprint. Since 2016, a high-fidelity drilling simulator has been established and tested for development and validation of Artificial Intelligence (AI) systems for drilling operations. The simulator can be accessed through a web Application Programming Interface (API) and run from a web client or as a Hardware-in-the-loop (HIL) simulator from a control system environment with programmable logic controllers (PLCs). The web enablement makes the simulator suitable for testing AI systems from anywhere in the world without any installation of software. The HIL functionality enables a workflow from early development stages to industrial pilots involving testing in a realistic environment. This paper describes the objectives of the project, the technical solutions, and the results obtained.

Keywords: AI systems, Process modelling, Process control, Simulator, Web-application programming interface.
nonlinear control systems under unbalanced disturbances. To address the problem, sliding mode observers are used. The suggested approach for constructing sliding mode observer is based on the reduced order model of the initial system. This allows to reduce complexity of sliding mode observer and relax the limitations imposed on the initial system, therefore a class of systems for which sliding mode observers can be constructed is extended.

Keywords: Nonlinear systems, Faults, Identification, Disturbances, Sliding mode observers.

Modeling and Analysis of Sensor Uncertainty for Non-Iterative Air Balancing Methods
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Air balancing must be conducted regularly in air duct systems to maintain accurate air supply and optimal working conditions. The non-iterative air balancing methods are gradually attracting interest for their low cost and high efficiency. The existing non-iterative air balancing methods relies heavily on flow measurement and can be greatly affected by sensor accuracy. To evaluate comprehensively the performance of an air balancing method, the robustness against sensor uncertainty should be considered and quantified appropriately. This paper proposes a mathematical model for non-iterative methods to predict the balancing performance in the presence of sensor uncertainty.

A New Sliding Mode Control Method for Discrete Network System with Bilateral Delay
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Aiming at the NCS with bilateral random network delay, this paper proposes a discrete sliding mode control method by constructing a sliding mode surface function which can compensate for the bilateral delay. Because of nonlinear-ity existing in the sliding mode controller, the controlled plant and the controller are modelled separately in this study. By introducing a sliding mode surface function that can compensate for the delay, the sliding mode control law is designed on the premise of satisfying the sliding mode reachable condition, and then the sliding mode of the system is obtained. Stability analysis of the sliding mode is given by Lyapunov stability criterion. The effectiveness of the proposed discrete sliding mode controller is verified by a series of experiments on the ball and beam system.

Keywords: Nonlinear systems, Faults, Identification, Disturbances, Sliding mode observers.

Stabilization of Nonlinear Networked Switched Control Systems with Delays and Packet Losses
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This paper studies the stabilization problem for nonlinear NCS(NNCSs) with bilateral network-induced random delay and packet dropout. T-S fuzzy model is employed to represent the nonlinear controlled plant. Based on the T-S model, a discrete-time fuzzy switched system model with uncertain parameters is established by means of the uncertain method and switching system method. Furthermore, the exponential stability condition for the state of the fuzzy switched system is obtained by using the combination of slow switching model-dependent average dwell time (MDADT) method and fast switching MDADT method. Finally, a numerical example illustrates the effectiveness of the proposed method.

Keywords: Nonlinear NCSs, T-S fuzzy model, Switched system, Mode-dependent average dwell time.
Non-live Sessions

P1349

Output Consensus of Heterogeneous Linear Multi-Agent Systems with Unbounded Distributed Transmission Delays

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The output consensus problem of heterogeneous linear multi-agent systems subject to unbounded distributed transmission delays is considered in this paper. A novel distributed output feedback control law is proposed and it is shown that the multi-agent system can achieve output consensus by the proposed control law under some sufficient conditions. One of the distinctive advantages of this work over existing works is that there is no restriction on either eigenvalues or initial conditions of the agents in spite of the existence of unbounded transmission delays. Moreover, our results can include some existing ones on consensus control with bounded or unbounded distributed delays as special cases. Finally, the effectiveness of the proposed control law is demonstrated by two simulation examples.

Keywords: Output consensus, Unbounded delays, Heterogeneous multi-agent systems.

Session [TT10] TT10 Control and Systems (IV)

P1444

An Air Balancing Method based on Distributed Finite-Time Control for the Ventilation Duct System

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Testing, Adjusting and Balancing (TAB procedure) is an important issue of air distribution systems. This paper proposes a distributed finite-time control-based air balancing (DFTC-AB) method for the ventilation duct system. It is employed by using the distributed finite-time control approach which can achieve air balance via exchanging information with neighboring terminals. Comparing with the traditional air balancing methods, the proposed DFTC-AB method has the following advantages. 1.) This method only need to communicate with neighboring terminals, thus eliminating the necessity of a centralized control unit. 2.) It is mode-free method that requires no system topology and parameters and is therefore easy to apply. 3.) The proposed method has a better convergence performance, which can reduce the convergence time. The experiment results verified the performances of the proposed method.

Keywords: Bipolar, DC microgrid, Unbalanced voltage, Distributed cooperative control.
Planning Method of Transportation and Power Coupled System Based on Road Expansion Model

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In this paper, a planning method of transportation-power coupled system based on road expansion model is proposed. First of all, based on the Wardrop equilibrium state, the traffic flow is distributed, to build the road expansion model and complete the traffic network modeling. It is assumed that the road charging demand is directly proportioned to the road traffic flow, and the charging facilities will cause a certain degree of congestion on the road. This mutual influence relationship to establish a coupling system of transportation network and power network is used for the planning. In the planning method, the decision variables include the location of charging facilities, the setting of energy storage systems and the road expansion scheme. The planning goal is to minimize the investment cost and operation cost. The CPLEX solver is used to solve the mixed integer nonlinear programming problem. Finally, the simulation analysis is carried out to verify the validity and feasibility of the planning method, which can comprehensively consider the road expansion cost and travel time cost, taking a coupled system of 5-node traffic system and IEEE14 node distribution network as example.

Keywords: Planning method, Coupled system, Road expansion, Transportation network, Distribution network.

Blended Methodology of Lateral Jet Simultaneous with Aerodynamic Fin for Integrated Guidance and Control of Flight Vehicle

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The design method of integrated guidance and control for flight vehicle with lateral jet and aerodynamic fin actuators is studied in this paper. By combining the relative kinematics between vehicle and target in three-dimensional space with the nonlinear dynamics of vehicle, a model of integrated guidance and control of flight vehicle is established firstly. In order to achieve accurate tracking of strong maneuvering target, an adaptive nonlinear control law of the integrated model for blending direct lateral jet force and aerodynamic fin force is proposed by using dynamic surface method. The vehicle relies on the lateral jets to generate direct force to speed up its attitude response based on daisy chain method of two kinds of actuators, and integer programming method is used to determine the start and stop of direct force. Based on Lyapunov theory and quantitative input idea, the stability of the closed-loop system under direct force and aerodynamic control is proved. Finally, the feasibility of the designed control law is verified by numerical simulation.

Keywords: Integrated guidance and control, Aerodynamic fin, Direct lateral jet, Blending control, Adaptive block dynamic surface, Quantized input.

A SMO Based Position Sensorless Permanent Magnet Synchronous Motor Control Strategy

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The position sensors are necessary for the permanent magnet synchronous motors (PMSM) in order to obtain the position feedback information, while also increasing the integrated system cost and the spatial occupancy, therefore, the research work for new type of position sensorless PMSM become a mainstream. The key technology of the new type motor is to obtain the position information without the position sensor. This paper proposes an improved sliding mode observer (SMO) based control strategy for PMSM. By using the improved SMO, the position and speed information can be estimated and used to form a complete closed-loop control system. Real time simulation of the proposed scheme is performed through a semi-physical simulation platform to verify the effectiveness of the proposed control strategy.

Keywords: PMSM, Improved Sliding Mode Observer, Position sensorless, Real-time simulation.

Research on the Influence of Chemical Combustion on the Modeling of Infrared Decoy

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Infrared(IR) decoy is a direct factor that reduces hit rate of IR guided missile, therefore, establishing an accurate IR decoy radiation model plays an important role in IR guidance algorithm. However, current CFD model of infrared decoy does not take the influence of infrared pyrotechnics combustion into consideration, directly declining the model.
Energy Management Method for Hybrid Energy Storage Tram Based on Equivalent Loss Instantaneous Optimization

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In order to improve the system efficiency and operational economy of hybrid energy storage (HES) tramway under cycle conditions, this paper presents an energy management method based on equivalent loss instantaneous optimization (ELIO) for lithium battery/supercapacitor hybrid energy storage system (HES) with dual DC/DC topology. The online convex programming method is used to solve the problem, and the optimal dynamic mixing degree at each moment of the system is obtained. This proposed method properly allocates the power flow between lithium battery and supercapacitor to minimum the system equivalent loss in the unit control period. According to the equivalent loss theory, the ELIO problem is converted to the optimal output power solution of the HESS. Under various operating conditions, the multi-index performance is tested and analyzed by a HESS test platform, which consists of lithium battery, supercapacitor, bidirectional DC/DC converter and energy management system. The experimental results show that compared with the power following strategy, this proposed ELIO method can effectively improve more than system efficiency, operational economy and driving mileage, and improved the service life of HESS by smoothing battery operating pressure.

Keywords: Hybrid energy storage system, Energy management method, Operational economy.

A Two-level Energy Management Model for Railway Substation with POC and Energy Storage

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A novel topology of railway traction substation integrated power optimization controller (POC), hybrid energy storage system (HESS) and photovoltaic (PV) generation system is studied in this paper. The railway station energy management strategy is divided into high-level and low-level, in which high-level optimizes energy flow of substation, and the low-level controls power redistribution of HESSes. The two-level energy optimization problem is expressed as mixed integer linear programming (MILP), the actual operation error of electric multiple unit (EMU) and PV is also taken into consideration. A real case is verified that the proposed method can reduce railway operating cost and improve usage efficiency of regenerative braking (RB) and PV.

Keywords: Railway energy management, Hybrid energy storage, Power optimization controller.
Virtual Inertia Adaptive Control Strategy for DFIG Wind Turbines Based on Exponential Function

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With the increase of the penetration rate of wind power in the grid, the influence of wind power grid-connected on the frequency of power systems is increasingly significant. Conventional wind turbines cannot maintain the same frequency as the synchronous machine because of their rotor speed, which causes the mechanical inertia of the wind turbines to not participate in the grid frequency adjustment. In this paper, an exponential function-based virtual inertia adaptive control strategy for double fed induction generators (DFG) is proposed. According to the frequency variation of inertia response, the virtual inertia adaptive parameters are adjusted to quickly suppress the frequency oscillation and provide inertia support. Finally, the simulation model is built in SIMULINK, which verifies the effectiveness of the proposed method.

Keywords: Energy storage system, Coordinated control strategy, Power flower controller.

An Advanced Traction Power Supply System in Electrified Railway

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Recent years, with the rapid development of high-speed railway (HSR), the negative sequence (NS) problems and the usage of regenerative braking energy (RBE) in electrified railway have aroused wide-spread attention from related areas. To address those problems, this paper proposed a new energy storage traction power supply system (ES-TPSS), which combine the power flower controller (PFC) and the energy storage system (ESS). Furthermore, a coordinated control strategy for ES-TPSS is presented to realize effective switching between different working patterns. Finally, the effectiveness of proposed system and its control strategy is verified by a simulation.

Keywords: Doubly-fed wind turbines, Exponential function.

Research on Intelligent Early Warning Algorithm for Distribution Network Considering Extreme Climate Conditions

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The distribution network is an important part of the power supply of the power grid, which is related to the safety and reliability of the power supply of the power grid. Under extreme climate conditions, the probability of failure of the power distribution network will greatly increase, and the occurrence of such failures is often difficult to prevent effectively. The reason why it is difficult to prevent is that extreme climate data belongs to non-electrical variables, while actual data of distribution network operation belongs to electrical variables. In this context, this paper proposes an intelligent mining algorithm for early warning of distribution network operation faults in an intelligent gateway. Data mining, and correlation analysis and causality analysis of data, so as to achieve a full range of early warning of distribution network operation failures. The intelligent early warning algorithm proposed in this paper can effectively mine and analyze climate data such as typhoons, ice disasters, thunderstorms, and extreme high temperatures, and obtain risk prediction results. Early warning and preventive control of the safe operation of the distribution network can be effectively improved The ability of the distribution network to cope with extreme weather conditions.

Keywords: Extreme climate, Distribution network, Intelligent early warning algorithm.

Comparison of ESS Configurations and IC Control Technologies in Isolated Hybrid AC/DC Microgrids

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Due to the Hybrid AC/DC microgrids (HMG) structure merges the advantages of AC microgrid and DC microgrid, it is a key step towards the future smart grid. In the isolated hybrid AC/DC microgrid (E-HMG), keeping the power balance and voltage/frequency regulation is chal-
This paper presents a methodology of optimal hybrid energy storage system (HESS) sizing, which includes a master problem of power and energy capacities configuration of HESS, and a slave problem of daily HESS operation. In the master problem, the total cost of power and energy capacities configuration of HESS is formulated with minimized electricity cost of CTSS. Grey wolf optimizer with embedded CPLEX solver is adopted to solve this HESS sizing problem. The proposed method is verified with a real case of high-speed railway line in China.

Keywords: AC/DC hybrid microgrids, ESS, Interlinking converter, Steady analysis, Power flow.

**P11590**

**Optimal Hybrid Energy Storage Sizing for Co-phase Traction Power Supply System Based on Grey Wolf Optimizer**

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This paper presents a methodology of optimal hybrid energy storage system (HESS) sizing, which includes a master problem of power and energy capacities configuration of HESS, and a slave problem of daily HESS operation. In the master problem, the total cost of co-phase traction substations (CTSS) during the project service period is minimized, with battery aging and replacement considered. In the slave problem, a formulation of mixed integer linear programming (MILP) is performed with minimized electricity cost of CTSS. Grey wolf optimizer with embedded CPLEX solver is adopted to solve this HESS sizing problem. The proposed method is verified with a real case of high-speed railway line in China.

Keywords: Co-phase traction power supply system, Hybrid energy storage, Battery aging, Grey wolf optimizer.

**P1464**

**Washout Filter-Based Decentralized Control Scheme for Economic Operation of Islanded AC/DC Microgrids**

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Economic operation is a fundamental issue for both islanded AC and DC microgrids. Conventionally, hierarchical control is commonly utilized to realize the economic operation of islanded microgrids. However, a layering of primary, secondary, and tertiary control may cause inco-ordination among different layers. To simplify the control schemes and realize the economic operation of islanded microgrids, a fully decentralized control scheme based on washout filter is proposed for both islanded AC and DC microgrids in this paper. The proposed control scheme can realize the economic operation and frequency restoration simultaneously for islanded AC microgrids, and can achieve the economic operation and voltage regulation at the same time for islanded DC microgrids without any additional control loops. Simulation results based on the studied islanded AC and DC microgrids are carried out to validate the effectiveness of the proposed control schemes for both islanded AC and DC microgrids. Keywords: Islanded microgrids, Economic operation, Washout filter, Frequency restoration, Voltage restoration.
Uncertainty Analysis of Wind Power Based on Levelized Cost of Energy

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With the development of wind power, the development of wind turbines (WTs) is becoming larger, and the uncertainty in the cost of WTs is also amplified. This paper proposes a levelized cost of energy (LCOE) model considering the rate of the production price index and consumer price index based on the gross domestic product. To analyze the uncertainty factors in this model, the Monte Carlo method and the quasi-Monte Carlo method are used to perform multiple experiments based on the wind speed parameters c and k and the probability density function (PDF) of the air density. The wind parameters are estimated by the mean variance method, the maximum likelihood estimation method, and the Bayesian estimation method. The PDF of LCOE and sensitivity analysis of various uncertainty factors on LCOE are obtained. The analysis results show that combining the local wind speed and air density parameters, the uncertainty factors that have a greater impact on LCOE are air density and wind speed parameter c. The air density should become an important factor to consider when considering LCOE of WT.

Keywords: LCOE model, Monte Carlo/ quasi-Monte Carlo method, Uncertainty analysis, Sensitivity analysis.

Detection of Users-Transformer Relationship in the Secondary Power Distribution System with Smart Data

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Due to frequent changes in settings at the secondary power distribution system, the records of the relationship between users and transformers do not update simultaneously. Relying on manual detections not only takes too much time but also requires special equipment. The paper proposes a method to detect the relationship between users and the transformer based on the distribution network operational data collected from smart meter. The method uses Principal Component Analysis (PCA) and Independent Component Analysis (ICA) to extract features from voltage time series data. The data in the paper is collected from local electricity utilities and the case study shows that using the proposed method can successfully identify the relationship between users and transformers with the voltage and current low-frequency time series data.

Keywords: Secondary power distribution system, Time series data analysis, Relationship detection, PCA-ICA.
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Review on Reliability Evaluation of Urban Integrated Energy System based on Multi-Source Data
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UIES (UIES) refers to the integrated energy system in which the main energy components are distributed in the city. In UIES, because of the coupling of many subsystems, such as power, heat, air conditioning, transportation, natural gas and communication system, in order to maintain stable production and operation, urban energy system must collect complex and multi-sources of data. In addition, the coupling characteristics between energy subsystems also bring difficulty to UIES. In this paper, the coupling model of UIES composed of different energy subsystems is studied, then the multi-source data composition of UIES is analyzed, and then the reliability evaluation of individual energy subsystem is discussed. Finally, taking the power-natural gas coupling system as an example, the types of multi-source data to be considered in the reliability evaluation of integrated energy system are analyzed. Through the review and analysis of the latest literature, it is expected to provide a reference for the reliability evaluation of UIES.

Keywords: UIES, Reliability evaluation, Multi-source data, Coupling property.

P1110
An Easy-to-Characterize Electrochemical Model for Lithium-Ion Batteries and Its Metaheuristic Parametrization
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Lithium-Ion batteries, Heuristics, Genetic algorithm.

This paper proposes a lithium-ion battery (LIB) characterization technique which combines a single particle model with metaheuristics including but not limited to the genetic algorithm (GA). The battery model is semi-empirical in that its active material parameters, which are difficult to characterize with experiments in practice or onboard (e.g., electrochemical impedance spectroscopy), are identified via heuristics. However, the single-particle model is also based on real physics, reflecting both solid diffusion phenomena and the Butler-Volmer dynamics in a linearized manner. The optimized model achieves a higher level of accuracy than the fully-empirical equivalent circuit model (ECM) in our benchmark study. Also, different temperatures and constant current draw (C-rate) conditions are tested to validate the model fidelity in various scenarios. The proposed model shows the potential of being embedded into a microcontroller thanks to its small footprint.

Keywords: Lithium-ion batteries, Heuristics, Genetic algorithm.

P1021
Intrinsic Thermal Couples for Measurement in High Temperature and High Heat Flux Environment
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We have developed a method to conduct measurement in high temperature and high heat flux environment. The method is based on sensors mounted on the back side of a specimen irradiated by high energy lasers. The sensor readings are used to calculate the front surface temperature and heat flux through inverse heat conduction computations. This paper presents a novel thermal couple arrays known as “intrinsic thermal couples”. A metal wire spot-welded to the metal specimen forms each intrinsic thermal couple. Aluminum and stainless steel specimens are tested. The experimental results show that these thermal couple arrays provide data that are rugged and uniquely suited for the high temperature and high heat flux environment.

Keywords: Sensors, Harsh environment, Inverse heat conduction problem.

P1467
Stochastic Model Predictive Control for the Yaw Control System of Horizontal-Axis Wind Turbines
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Model predictive yaw control (MPYC) using the future wind direction information could improve energy conversion efficiency of wind turbines. However, the performance of MPYC system is closely related to the wind direction prediction of which the accuracy is actually difficult to improve. In this paper, we propose a stochastic model predictive yaw control (SMPYC) based on multi-scenario optimization to solve the uncertainty of future wind direction prediction. Meanwhile, in order to reduce computational burden during the model solving, the synchronous backward substitution method is used to cut down the scenarios with guaranteed precision. Then, the performance of the proposed SMPYC method is demonstrated by the simulation tests comparing with baseline control method (MPYC). Finally, our results show that the overall performance including power production and yaw actuator usage of SMPYC is enhanced.
Multi-Objective Capacity Optimization of Integrated Energy System with Compressed Air Energy Storage

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This paper proposes a multi-objective capacity optimization method to determine the size of the integrated energy system (IES). A novel IES configuration composed of wind turbine, solar photovoltaic, combined cooling, heating, and power system, and compressed air energy storage is designed, which could improve energy efficiency and reduce emissions. Based on a developed modeling of all sub-systems composing the IES, the capacity is optimized to minimize the net present cost and environmental cost simultaneously. Non-dominated sorting genetic algorithm-II (NSGA-II) is applied to find the Pareto frontier of the constructed multi-objective formulas. Finally, taking an industrial park located in Jinan, China, as an example, the optimization results using the proposed approach provided a set of design solutions for the investor to select the optimal configuration.

Keywords: Integrated energy system, CAES, Multi-objective, Capacity optimization.

A Study on Low-Temperature Model Parameter Identification of LTO Battery by Cuckoo Search

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The parameters of the LTO battery model are quite different between low temperature and room temperature conditions, which causes unacceptable errors in existing State of Charge (SOC) estimation model at low temperatures. In order to establish a precise LTO battery model, which can be applied to the State of Charge (SOC) estimation at both room temperature and low temperature, a method for identifying parameters of LTO battery model under low temperature is proposed. Firstly, the terminal voltage data during the discharge process of LTO battery at different temperatures are obtained through the test. Secondly, the data is imported into the Cuckoo Search with other optimization algorithms aiming at identifying the parameters of the second-order RC model at different temperatures, which are then applied to the model to obtain the estimated terminal voltage curves. Finally, the obtained estimated terminal voltage curves are compared with the actual values on curves, which shows that Cuckoo Search owns a higher accuracy and its identification results are applicable to the State of Charge (SOC) estimation of LTO battery within a wide range of temperature, especially at low temperatures.

Keywords: Temperature, LTO battery, SOC, Second-order RC model, Cuckoo search.
Research on SOC Estimation of Lithium Battery based on GWO-BP Neural Network
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Aiming at the problem of inaccurate estimation of state of charge (SOC) in lithium battery applications, this paper proposes a SOC estimation model based on Grey Wolf Optimizer (GWO) and BP neural network. This model takes the terminal voltage and discharge current of the lithium battery as the input terms of the neural network and the battery SOC as the output term. The traditional BP diagnostic model and the new model are trained and tested using the test data at different discharge rates. Experiments with measured data indicate that compared with the traditional BP diagnos-
tic model and the new model are trained and tested by using Particle Swarm Optimization (PSO) and mixed inte-
gers for calculating accuracy. While using Singular Value Decomposition for calculating accuracy, the experiments indicate the accuracy of the battery SOC can be within 3%, and it has good stability which meets the actual demands.

Keywords: Lithium battery, SOC, BP neural network, GWO algorithm.

The accurate estimation of the State of Charge (SOC) of a battery is an essential function in battery management system. Kalman filter algorithm is commonly used for SOC estimation. However, the existing Kalman filter algorithm has drawbacks such as low frequency and poor calculation stability when performing SOC estimation. In this paper, an Improved Unscented Kalman Filter (IUKF) which is based on Singular Value Decomposition (SVD) is used, this algorithm uses traceless transformation for accuracy improving, while using Singular Value Decomposition for calculation stability. The experiments indicate the accuracy of the battery SOC can be within 3%, and it has good stability which meets the actual demands.

Keywords: State of charge, Improved unscented Kalman filter, Singular value decomposition.
P1623
Stereo Refinement Based on Gradient Domain Guided Filtering
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The weighted median filtering with bilateral weights is currently a popular solution for disparity refinement in stereo vision, but computational complexity is an issue. In this paper, a linear disparity refinement approach based on the gradient domain guided image filtering (GDDGF) is proposed. The advantage of the proposed method is that the weights are adaptive to image structure. As such, the proposed method can remove errors in small regions, similar to salt-and-pepper noise, and large areas while edges are well preserved. Experimental results show that the proposed method can improve accuracy of disparity maps and the edges in disparity maps are better preserved than those by the state-of-the-art algorithms. Especially, the proposed disparity refinement is more efficient.
Keywords: Stereo matching, Guided filter, Gradient domain guided filter, Disparity refinement.

P1150
Image Based Visual Servoing for Landmine Detection using Quadrotors
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This paper presents a technical approach for landmine detection with quadrotors using image based visual servoing (IBVS) on thermal images. Considering the difference in temperature between the ground soil and possible buried targets, thermal images are used to estimate target position in an uncalibrated Kalman filter framework: accelerometers, gyroscopes and GPS measurements are integrated in loosely coupled manner as the navigation solution. At first, the quadrotor quipped with single thermal camera estimates the target’s depth by following a special ellipsoid trajectory and then using IBVS, it approaches to the target up to one meter distance. In order to control the drone to flight close to the ground, a ground effect compensated controller is also considered in the implementation. Results show that for landmine detection purposes using IBVS on thermal images, with ground effect compensated control, an overall error around 20 pixels is achievable.
Keywords: Quadrotor, IBVS, Visual servoing, Ground effect, Thermal imaging, Landmine detection.

P1320
Dynamic Augmented Kalman Filtering for Human Motion Tracking under Occlusion Using Multiple 3D Sensors
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In this paper real-time human motion tracking using multiple 3D sensors has been demonstrated in a relatively large industrial robot work cell. The proposed solution extends state-of-the-art by augmenting the constant velocity model and Kalman filter with low-pass filtered velocity states. The presented method is able to handle occlusions by dynamically inclusion in the Kalman filter of only those 3D sensors which provide valid human position data. Human motion tracking was achieved at a frame rate of 20 Hz, with a typical delay of 50 ms to 100 ms and an estimation accuracy of typically 0.10 m to 0.15 m.

P1101
Humanoid Muscle-Skeleton Robot Arm Design and Control Based on Reinforcement Learning
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Muscle-skeleton robots share similar appearances and functions with humans, making these robots more adaptive in human interaction scenarios. In this paper, a novel muscle-skeleton robot arm driven by artificial muscles is proposed. First, we design a new multifilament McKibben muscle and measure its properties. Then a humanoid robot arm referred to the anatomy of the human arm is presented, while the configuration of muscle is adjusted to reduce the complexity of manufacturing and controlling. Muscle-skeleton robot arms with different muscle configurations are controlled using the reinforcement learning method in the simulation environment, and different arm models’ movement ranges are obtained to find the best muscle configuration. The experimental results show that the model with the best muscle configuration achieves 79.8% of the whole movement range.
Keywords: Humanoid robot arm, Multifilament McKibben muscle, Reinforcement learning.
Guidelines to Select Between Self-Contained Electro-Hydraulic and Electro-Mechanical Cylinders

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This research paper presents guidelines on how to select between self-contained electro-hydraulic and electromechanical cylinders. An example based on the motion control of a single-boom crane is studied. The sizing process of the different off-the-shelf components is analyzed in terms of design impact when replacing a traditional valve-controlled hydraulic cylinder. The self-contained electro-hydraulic solution is the best choice when a risk for high impact forces is present, when the required output power level lies continuously above 2 kW, or when installation space, weight, and cost are critical design objectives. However, the electromechanical solution is expected to show more controllability due to the fact that it has higher levels of drive stiffness, and energy efficiency as well as lower system complexity. This solution also requires less effort to control the actuator’s linear motion accurately. All of these factors result in a more straightforward design approach.

Keywords: Hydraulic systems, Electric drives, Self-contained actuators, Linear actuators, Actuation system design, Component selection, Electro-mechanical cylinders, Electro-hydraulic cylinders, Valve-controlled cylinders, Load-carrying applications.

A Dynamic Surface Controller based on Adaptive Neural Network for Dual Arm Robots

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The paper introduces an adaptive controller to efficiently manipulate the dual arms of a robot (DAR) under uncertainties including actuator nonlinearities, system parameter variations and external disturbances. It is proposed that by the use of the dynamic surface control (DSC) method, the control strategy is first established, which enables the robot arms to robustly operate on the desired trajectories. Nevertheless, the dynamic model parameters of the DAR system are unknown and impractically estimated due to its uncertain nonlinearities and unexpected external factors. Hence, it is then proposed to employ the radial basis function network (RBFN) to adaptively estimate the uncertain system parameters. The Lyapunov theory is theoretically utilized to derive the adaptation mechanism so that the stability of the closed-loop control system is guaranteed. The proposed RBFN-DSC approach was validated in a synthetic environment with the promising results.

Keywords: Dynamic surface control, Sliding mode control, Dual arm robot, Radial basis function, Lyapunov method.

Laser Triangulation 3D Point Cloud Sensor with Long Range and Large Field of View

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This paper presents a point cloud sensor design based on laser triangulation. Both the camera axis and the laser axis are rotating, making it possible to scan on short and long range in high resolution. A third axis moves the laser and camera into a new plane. The design is tested on a working prototype. To the authors' knowledge a similar design has not been presented before.

Keywords: Sensor, Short range, Long range, 3D point cloud, Triangulation.

A Sign Language Interaction System Based on Pneumatic Soft Hand

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The interaction with the deaf-mute is an important part of human-computer interaction. In response to the application requirements of human-computer interaction technology in the deaf-mute field, this paper proposes a kind of human hand movement system that can control the soft hand to interact with human according to the sign language action. The system proposed a way to simplify the definition of human hand movements and then implemented the movement detection of the human hand, the creation of a human hand shape, and also the mechanical structure capable of sign language actions. Through various experiments, the tracking ability and interaction ability of the soft hand to the human hand movement were demonstrated, and the information of the human hand movement was collected and analyzed. The system has extensive engineering potentials in the application of sign language interactive terminals and other related aspects.

Keywords: Sign language, Pneumatic soft hand, Interactivity.
An Adaptive Backstepping Control Method for Lower-Limb Exoskeleton Robot

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This paper presents an adaptive backstepping controller (ABC) for lower extremity exoskeleton robot which driven by DC motors. For some nonlinear system which has some uncertain parameters, the controller may be worsens the system and even causes the system to be unstable when system suffer external interference or parameter drift. So we show an adaptive backstepping controller to adapt those circumstance. In order to complete the design of adaptive backstepping controller, We model and simulate a manipulator with a degree of freedom under the circumstance of system has some uncertain parameters, then we compare our simulation with PID feedforward controller.Finally we design the adaptive backstepping controller for the low-limb exoskeleton system, then we show the result of simulation and experience. The result shows ABC is adaptive to parameter drift compared to conventional control methods.

Keywords: Exoskeleton Robot, Adaptive, Backstepping.

Application of Image-Based Visual Servoing on Autonomous Drones

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This work presents an Image-Based Visual Servoing (IBVS) technique for an autonomous drone to track and follow an object in 3D space using Image-Based Visual Servoing. Unlike implementing tracking mechanism using GPS information, Radars or other high-level position determining devices, we present our approach in which we use an onboard camera that captures realtime video stream to process information such that a given target in 3D space is tracked. We perform IBVS during the flight. A technique to use the video stream and locate the target is presented in this paper. Here we also discuss the mathematical model and system architecture of this technique on an autonomous drone. The advantage of this approach is that the tracking by drones can be made completely autonomous even in GPS-denied environments. We then walk through the applications and future scope of this methodology.

Keywords: Image-based visual servoing, Aerial vehicles, Drone control, Object tracking, Image processing.

A Agricultural Spraying and Fertilization Robot based on Visual Navigation

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The research and popularization of agricultural intelligence and automation is the guarantee of modern agriculture. At present, Autonomous navigation of agricultural fertilization robot can effectively reduce the use of labor, and greatly improve the work efficiency, which has become the focus point of agricultural robot research. In this paper, a agricultural fertilization robot with autonomous navigation was studied, also a roller piercing fertilizer applicator was designed and developed, which can avoid the waste of surface fertilization, and improve fertilizer efficiency. The robot mainly includes the control of chassis, farmland image processing, navigation path planning and mechanical design of spraying and fertilization. For robot control, the Cortex-m4 is selected to control the motors of chassis. For farmland image processing, through the color space selection, filtering, enhancement, and segmentation, the useful information can be obtained for visual navigation. The Raspberry Pi is employed to process the image information. Through serial communication, Raspberry Pi can send instructions to Cortex-m4 for controlling robot chassis and receive the feedback. Because the Raspberry Pi takes a long time to completely process the image, the image processing navigation algorithm is improved. By comparison, the processing speed has been increased by four times, which effectively guarantees the realtime of robot autonomous navigation. The experiments results show that the robot is suitable for arid areas and can be used for deep fertilization, the improved algorithm can effectively enable the robot to carry out for autonomous navigation, fertilizing and spraying.

Keywords: Agricultural robot, Visual navigation, Image processing, Fertilizing and spraying.
A Brief Survey: Deep Reinforcement Learning in Mobile Robot Navigation
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Conventional navigation techniques have mainly relied on a global information approach, wherein pre-built laser or camera environment maps are used to construct a path from a given start to destination. While these methods have seen success, they are mainly confined to operate in simple and relatively static environments. Not only is substantial effort required for prior mapping, there is no ability for these navigation systems to learn and generalize to new unseen places. These related problems have motivated researchers to turn to machine learning approaches. In particular, the advent of Deep Reinforcement Learning (DRL) has shown much promise in tasks like context- awareness, navigating in dynamic environment, and map-less navigation. This paper attempts to survey some recent DRL papers, examining the underlying foundation for applying DRL to navigation, and highlighting five key limitations: (1) low sample efficiency, (2) the gap from simulation to real, (3) vulnerability to being trapped in local dead corners, (4) deficient collision avoidance in dynamic environments such as multi-pedestrian and multi-agents environments, (5) and lack of proper evaluation benchmark. We argue that these limitations must be addressed before the pervasive use of service robots in human society.

Keywords: Robot navigation, Deep reinforcement learning.

Navigation Path Curve Extraction Method Based on Depth Image for Combine Harvester
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Autonomous harvesting plays an important role in Precision agriculture. Navigation path extraction is the premise of autonomous harvesting for combine harvester. The existing navigation path extraction methods are mainly based on color space. The color space of farmland is easily affected by illumination, shadows, weeds, etc. For different crops, the color characteristics are very different, such as rice, wheat and sorghum. In contrast, the depth information is basically unaffected by these. This paper proposes a navigation path curve extraction method by using depth image. The depth image can generate 3D point cloud to be further processed. The downsampling of the point cloud is implemented by voxel filtering to reduce the amount of calculation. The unharvested area is fitted to a plane by Random Sample Consensus (RANSAC). The region of interest (ROI) is set according to the height threshold. The boundary points are clustered adaptively according to the distance between the point and the unharvested plane. The boundary points are clustered according to the height threshold. The boundary points are used to fit the navigation path curve. The experiments in farmland show an average detection accuracy of boundary points is 99.0%. The average processing time of frames is 45ms. The experiment results satisfy the navigation path accuracy and real-time requirements. The paper provides an effective navigation path detection curve method.

Keywords: Depth image, 3D point cloud, Navigation path curve, Combine harvester, Farmland.
be applied to most welding and spraying tasks with general location accuracy requirements. At the same time, the binocular camera or RGB-D depth camera can be used to replace the monocular camera in this paper, so that the method can be extended to three-dimensional stereo application scenarios.

Keywords: Robot teaching, Machine Vision, Curve Fitting, Industrial Robot.

P1189
A Wearable Body Motion Capture System and Its Application in Assistive Exoskeleton Control
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Wearable intelligent device has become a hotspot in the research of human-computer interaction system. A representative example is exoskeleton robot, which has already been applied in rehabilitation, assistance, and even in military field. In order to guarantee man-machine coordination, and to achieve a reasonable performance, proper control has to be implemented according to the wearer’s body motions, and body motion capture system is necessary in this process. In this paper, a wearable body motion capture (WBMC) system is designed based on inertial measurement unit (IMU) and IEEE 802.11b wireless communication, and demonstration application in assistive exoskeleton control validate the proposed WBMC system.

Keywords: WMCS, Assistive exoskeleton, IMU.

P1270
A Bio-inspired Spiking Neural Network for Control of A 4-DoF Robotic Arm
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This paper explores the control task of a 4-DoF robotic arm via a Spiking Neural Network (SNN). Inspired from the biological neuron control mechanism, the SNN is proposed and analyzed for the robotic arm control. The SNN adopts a data-driven way to estimate the kinematic properties of the robotic arm and further spares the difficulty of analytic model building. Biologically, the desired target position and sensory information are processed into the network, and the patterns of motor commands are able to extract from the readout layer of the SNN. Finally, numerical studies are conducted to verify the effectiveness of the proposed SNN.

Keywords: Spiking neural network, Robotic arm, Tempotron, Bio-inspiration.

P1611
Controlled Propulsion of Asymmetric Janus Microdimer Swimmers under Rotating Magnetic Fields
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Untethered micro-/nanorobots at low Reynolds numbers present significant potential in biomedical applications as result of their enhanced power, remote actuation, and versatility. Herein, a highly efficient asymmetric Janus microdimer swimmer propelled by a rotating uniform magnetic field was investigated experimentally. The asymmetric microdimmers can achieve speed of 98 µm·s−1 at 20 Hz and 5 mT. Besides, the controllable and flexible motility performance of microdimer motors can be easily obtained by adjusting the magnetic field. Such an asymmetric Janus microdimer swimmer is highly promising in a variety of realistic micro-/nanoscale scenarios.

Keywords: Asymmetric microdimers, Rotating magnetic field, Propulsion mechanism.

P1115
Study on Temperature Rise Test of Valve Bridge Arm Reactor for VSC-HVDC System Based on Equivalent Loss
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Aiming at the difference of DC and AC harmonic current characteristics between valve bridge arm reactor for VSC-HVDC system and conventional DC smoothing reactor, based on the Yunnan asynchronous interconnection project, this paper studies and presents the necessity of additional AC temperature rise test for bridge arm reactor, based on equivalent loss principle, recommends AC temperature rise test methods and compares temperature rise experiments to conventional DC and AC dry-type air-core reactor. Results show that firstly, the methods of temperature rise design and test for bridge arm reactor should not simply follow those methods for conventional DC smoothing reactor based on DC current distribution characteristics and AC dry-type air-core reactor based on AC current distribution characteristics, secondly, the bridge arm reactors for Yunnan asynchronous interconnection project meet the temperature rise limit value requirements in AC-DC combined current. Finally, the test method of temperature rise of bridge arm reactor for VSC-HVDC in this paper
Winding Temperature Analysis of 3-D Wound Core Transformer Under Overload and Short-Circuit Conditions
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Wound core transformer is widely used in power distribution because of its low no-load loss and small size, which required to withstand overload and sudden short-circuit conditions due to load variation, so it is necessary to predict and simulate the overload and short-circuit tolerant capability of the transformer. In this paper, a finite element methodology based on electromagnetic-fluid-thermal coupling for the analysis of a 3-D model of dry-type wound core transformer is proposed. The loss distribution of the transformer is calculated under rated, overloaded and short-circuit conditions, respectively, which is taken into the fluid-thermal field account for analysis of transformer as heat source. The influence of temperature change on air parameters is considered for better accuracy. It is found that the 3-D wound core transformer has the capability to withstand 1.2 times overload capacity and the successive running time is obtained under different overload levels. Moreover, the simulation results show that the transformer is unable to withstand repeated short-term short-circuit conditions due to the cumulative effect of winding temperature. The results are compared with the empirical formula proposed in International Electrotechnical Commission standard, which proves the validity of the finite element method coupled with electromagnetic-fluid-thermal field.

Keywords: Wound core transformer, Wind temperature, Hot spot, Fluid-thermal analysis.

A Non-Contact SiC Power MOSFETs Health Status Monitoring Method Based on Magnetic Field Detection Technology
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The long-term reliability of power modules is a key factor for most of the power electronics device. Silicon carbide (SiC) devices are entering the market gradually as the new-generation power electronics semiconductors. Previous work of health condition monitoring is mainly for silicon devices and a few are for silicon carbide (SiC) modules among which there are still many problems such as isolation and accuracy. Magnetic field has been widely used in fault detection in many other areas as a good sensor which is contactless and sensitive. In this case, this paper proposes a non-contact SiC MOSFET health condition monitoring method based on magnetic field detection technology. The identification and measuring technique are tested on a platform showing that the method is promising for health condition monitoring of SiC MOSFET.

Keywords: Condition monitoring, SiC MOSFET module, Magnetic field, Comparative experiment.

250kW High-Frequency Transformer Design and Verification for MVDC Collection System for Renewable Energy Resources
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In the medium-voltage dc collection system for renewable energy sources, the high-power high-frequency transformer is one of the key equipment. To lower down the parasitic capacitance of high-power high-frequency transformer, the multi-layer and multi-section structure is adopted for the secondary winding. Furthermore, the multiwinding output series structure on the high-voltage side is employed as well, which is beneficial to reduce the voltage stress and voltage sharing difficulty of the rectifier diodes. A special bobbin is designed to implement the multi-winding output series structure. At last, a 250 kW high-frequency transformer is designed and manufactured with the good performance verified.
This paper demonstrates a new concept to enhance transient current overshoots for the low-side paralleled SiC MOSFETs in series: an additional fault characteristic value. The fault feature extraction method only needs to analyze the three-phase DC capacitors and the auxiliary gate-source connections is used to monitor collector current during normal circuit operation and to detect SC events.

Keywords: IGBT, Depletion-Mode MOSFET, Short circuit, Current sensing.

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P1031
A Paralleled SiC MOSFET Half-bridge Unit With Distributed Arrangement of DC Capacitors
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Discrete silicon carbide (SiC) MOSFETs are often connected in parallel to reach high current capabilities. However, the unequal switching losses and transient current overshoots can limit the maximum switching frequency and current capability of the paralleled unit. In this paper, a paralleled half-bridge unit with the distributed arrangement of DC capacitors and the auxiliary gate-source connections is presented. The layout mismatches are analyzed and optimized by the AnsysEM simulation techniques. Compared to the traditional paralleled unit, the differences in the transient current overshoots for the low-side paralleled SiC MOSFETs are decreased significantly from 14.37 % to 2.78 %.

Keywords: Parallel connection, Silicon Carbide (SiC).

P1036
Rotating Power Electronics for Electrical Machines and Drives – Design Considerations and Examples
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The industrial shift towards rotating power electronics (RPE) promotes brushless flexible rotor excitation, as well as battery-less rotor instrumentation and measurement devices for electrical machines. Recently, the high-power thyristor converter has been proven to be excellent for rotating applications. Moreover, MOSFET components have been successful for lowpower rotating applications. However, the question arises whether IGBT’s, capacitors and related components are able to withstand the centrifugal forces that are generated due to shaft rotation. In fact,
the manufacturers do not conventionally test their power electronic components against cyclic accelerational forces. Moreover, the insulation material in some types of semiconductor modules is viscous and will be affected by rotational forces. This paper addresses the current design challenges and presents new design criteria for RPE systems and applications. Finally, this paper reviews the current technology status for RPE concepts.

**Keywords:** Rotating Power Electronics (RPE), Monitoring, Internal processes, Rotating rectifiers, Thyristor rectifiers, IGBT converter, Rotating capacitor, Rotating chopper, Rotor field excitation, Brushless electrical machines.

**P1618**

**DC-DC Converter Control for Peak-Shaving in Shipboard DC Power System via Hybrid Control**

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For the stable operation of the shipboard hybrid DC power systems, the DC bus voltage should be controlled within the recommended range by the regulations. However, the challenge comes from the load variations, and it makes the main bus voltage fluctuate. This paper proposes a control approach based on hybrid dynamical modeling of the DC-DC converter for the battery interface. In this method, the switching signal of the DC-DC converter is calculated to satisfy the Lyapunov stability criteria, and the reference power of the battery is generated for the peak-shaving of the load changes to stabilize the voltage. The effectiveness of the controller is evaluated with real ship load data which has a transient profile. The performance of the proposed control strategy is presented, and the results show that the proposed method can provide significant advantages in terms of fast and stable control performance, as well as the peak shaving function by the battery to operate the diesel generators at the best efficiency point.

**Keywords:** DC-DC converter, Hybrid dynamical system, Peak-shaving, Batteries, Onboard DC power system, Hybrid electric ships.

**P1175**

**Accurate Reactive Power Sharing and Harmonic Mitigation in Isolated Microgrids Using Adaptive Virtual Capacitance**

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With the development of DC Microgrid, the DC circuit breaker has been highly concerned as a main protection equipment. Aiming at the application and performance requirements of DC circuit breaker, combined with the advantages of the third generation semiconductor GaN, this paper introduces a limited DC solid-state circuit breaker (SSCB) based on GaN. At first, the topology and control principle of SSCB are analyzed. Then, the mode transition process and control strategy of SSCB under starting inrush current, overcurrent or short current are discussed in later sections. Finally, the SSCB simulation model based on GaN is built. The simulation results show that the circuit breaker can limit the current quickly and break accurately under overcurrent or short circuit conditions, verifying the feasibility and effectiveness of the control strategy.

**Keywords:** DC solid state circuit breaker, GaN, current-limiting, Fast and accurate break.
This paper presents an adaptive virtual capacitance control method for distributed generation (DGs) in an islanded microgrid to mitigate the voltage harmonics at the point of common coupling (PCC). To achieve the control target, the proposed method emulates the inverter output capacitance at the dominant harmonic frequency to compensate for the mismatched voltage drop on the line impedance. In addition, the virtual capacitance at the fundamental frequency is regulated to improve the reactive power sharing performance of the inverter units. The proposed capacitance control method is developed based on simple integral controllers without prior knowledge of the feeder impedances and local nonlinear load currents. By continuously adjusting the inverter output capacitance, the microgrid power sharing performance and voltage quality are ensured despite any load changes. The effectiveness and superiority of the proposed strategy are theoretically analyzed and verified.

**Keywords:** Inaccurate reactive power sharing, Islanding microgrid, Harmonic voltage mitigation.

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Session [TT20]  TT20: Power Electronics (III)

**P1296**

**Simulation of Photovoltaic Absorption Strategy for Distribution Network Considering Translational Load**

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Large scale photovoltaic grid connection will lead to the voltage over the limit of node voltage in distribution network. In view of the problem of photovoltaic discarding caused by the voltage limit, an optimization model for coordinated scheduling is established in this paper. The objective of this model is to minimize the light weight of photovoltaic and to optimize the target by means of a variety of measures including the SL, the coordinated photovoltaic power and the static var compensator. Because the power flow equation in the model is nonconvex and nonlinear, the two order cone relaxation of the load flow equation is used to transform the model into a convex optimization problem. To consider the difference in the duration of shiftable load, this paper models it. Finally, in this paper, a typical distribution network in Feixi county is selected as an example to simulate and compare the three scenarios of photovoltaic degradation, proving the correctness and feasibility of the establishment of the model.

**Keywords:** Grid connected inverter, High permeability, Coordinated dispatching, Photovoltaic consumption, Pre optimization, Shiftable load.

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**P1394**

**Risk Assessment of Static Voltage Stability Based on Power Electronic Load Uncertainty Modeling**

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As a typical representative of load-side power electronic technology, the increasing popularity of electric vehicles such as electric vehicles (EVs) on the static voltage stability of distribution networks cannot be ignored. According to the uncertainty of the space-time distribution of the charging load, this paper presented a risk assessment framework of static voltage stability in the power system that takes into account the uncertainty. Power Electronic Load uncertainty modeling consisted of three steps: Modified fuzzy cluster method (FCM), Cholesky decomposition and multi-dimension normal distribution sampling method were adopted to get initial load profile; A probability hypercone load growth model was proposed based on Monte Carlo method to simulate stochastic variation of loading direction and power factor; One evaluation system combining correlation coefficient with mutual information was used to evaluate the uncertainty model. A simulation example shown that the proposed Monte Carlo - continuation power flow method for distributed generation (DGs) in an islanded microgrid to mitigate the voltage harmonics at the point of common coupling (PCC). To achieve the control target, the proposed method emulates the inverter output capacitance at the dominant harmonic frequency to compensate for the mismatched voltage drop on the line impedance. In addition, the virtual capacitance at the fundamental frequency is regulated to improve the reactive power sharing performance of the inverter units. The proposed capacitance control method is developed based on simple integral controllers without prior knowledge of the feeder impedances and local nonlinear load currents. By continuously adjusting the inverter output capacitance, the microgrid power sharing performance and voltage quality are ensured despite any load changes. The effectiveness and superiority of the proposed strategy are theoretically analyzed and verified.

**Keywords:** Inaccurate reactive power sharing, Islanding microgrid, Harmonic voltage mitigation.
Non-live Sessions

P1403

Research on UPS Filter Based on Passive Damping and Harmonic Trap
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The structure and parameter optimization of filter has an important effect on UPS output waveform quality as well as its size and weight. In this paper, approaches to improve LC filter which is commonly adopted in inverter are studied and a combination of passive damping and harmonic trap is used to optimize the filter structure. Firstly, an investigation of passive damping methods is presented, including the comparison of characteristics between RC damping circuit and R C2 damping circuit. After that, the selection guide of damping parameters is put forward based on the analysis of circuit parametric effect on quality factor. Secondly, the research on attenuation of harmonics at switching frequency is carried out which leads to the introduction of the two trap filter, series LC trap and parallel LC trap. Moreover, the circuit parameter’s effect on trap filter bandwidth is analyzed. Finally, two types of filter structure including LC trap, LC-RC and LC-RC-LC trap are proposed and the characteristics of the two filters are also analyzed. The effectiveness of the proposed filters of UPS inverter was verified by simulation and experimental results.

Keywords: Filter, Passive damping, Active damping, Harmonic trap.

P1518

Research on Control Strategy of Photovoltaic Grid Connected Converter Under Voltage Distortion
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Aiming at the problem that the power grid voltage distortion caused by non-linear loads such as electric arc furnace loads in the distributed power grid causes photovoltaics to fail to be effectively connected to the grid, a dynamic analysis of the distribution network voltage is required and a new phase-locked loop based technology is used. The control strategy of the grid-connected converter is to reduce the harmonic distortion rate when the photovoltaic grid is connected to the grid and improve the quality of the grid-connected current and grid-connected voltage. A typical dynamic model of the electric arc furnace and a Photovoltaic system model are established. By analyzing the impact of the electric arc furnace model on the grid-connected photovoltaic grid-connected converter with a traditional phase-locked loop when it is connected to the grid, a self-regulating Control Strategy of SOGI’s Phase-locked Loop Photovoltaic Grid-connected Converter. Finally, the arc furnace simulation module and photovoltaic system simulation module were customized through the PSCAD / EMTDC software platform, and the feasibility of the control strategy was verified through simulation analysis.

Keywords: Electric vehicle, Load uncertainty, Monte Carlo method, Static voltage stability.

P1061

Analysis of Id-Iq Strategy for Active Power Filter
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This paper presents a control strategy about an Active Power Filter (APF) topology; the main motto is to mitigate harmonic current. The considered solutions are as follows a newly present Active filter topology. In this paper the inverter power rating is the main focus part because it roughly determines the overall cost of the device. In an Active power filter, the active part is used to filter out the higher order harmonics, while lower order harmonics are eliminated by Compensator component. Analyzing the advantages and drawbacks of the chosen topologies try to present throughout in this paper. The performance of these topologies evaluated with a detailed MATLAB simulation-based investigation. The simulation results of Active power filter (APF) control technique, carried out in MATLAB environment, are presented in this paper. From the simulation, can be obtain a result, to eliminate harmonics and reactive power components from the utility current.

Keywords: Active power filter, Voltage distortion, Photovoltaic system, PLL, PSCAD/EMTDC.
Analysis of Energy Feed System of Metro under Adaptive Moment of Inertia VSG Control
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Because of the short distance between subway stations, frequent starting and braking, a lot of energy will be produced during regenerative braking. The traditional regenerative braking energy utilization scheme of inverter feedback type can feed back the energy to the AC power grid, but the inverter control technology is single, lacking the inertia and damping of synchronous generator, which can not provide high-quality frequency and voltage support for the distribution network. Virtual synchronous generator (VSG) introduces the moment of inertia and damping coefficient of synchronous generator into the control of inverter, enhances the anti-interference ability of power grid, and the virtual inertia and damping coefficient are flexible and adjustable. Therefore, based on the analysis of the VSG control strategy, combined with the VSG power angle curve, this paper studies an adaptive moment of inertia VSG control strategy, and applies it to the subway energy feed system. Finally, the simulation model of the system in Matlab / Simulink environment is built. The results show that: compared with the traditional inverter control technology, when the scheme is disturbed, the frequency and related loss is reduced especially in light-load mode. Simulation results verify the feasibility of the studied technique. A 400V prototype has been built to verify the effectiveness and advantages of studied method.

Keywords: Virtual synchronous generator, Regenerative braking energy, Energy feedback, Moment of inertia, Adaptive control.

A Cost-Effective Controlled-Type ZVS Technique for GaN-Based Totem-Pole PFC Rectifier
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In this paper, a controlled-type ZVS technique for totem-pole PFC rectifier with limited maximum switching frequency operating in boundary conduction mode and discontinuous conduction mode is studied. Conventional ZVS methods for totem-pole PFC rectifier may require detecting zero crossing point of inductor current or implanting auxiliary circuits. To avoid this, a cost-effective ZVS technique based on software calculation without hardware circuits is studied. SR conduction time extension is applied to compensate the non-ZVS region. By limiting the maximum switching frequency near zero crossing point of AC grid voltage or in light-load mode, the totem-pole PFC switches between BCM and DCM. Therefore, frequency-related loss is reduced especially in light-load mode. Simulation results verify the feasibility of the studied technique.

Keywords: Totem-pole PFC, ZVS, BCM, DCM, Variable switching frequency.

Controlled Three-Phase LCL-Filter PWM Rectifier with BESS-oriented Applications Under Unbalanced Grid Conditions
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The present paper aims to analyze the Battery Energy Storage System (BESS), which is connected to the grid in the distribution network, exclusively when it is operating as a battery charger under unbalanced grid voltage. The hypothesis establishes that it is possible to ride through an unbalanced voltage condition (typically caused by unsymmetrical loads, unsymmetrical transformer windings and transmission impedance) by using a nonlinear controller based on inputoutput linearization using only the current loops for each phase and generating the current references based on the balanced power. The methodology is based on the use of the mathematical model for a three-phase LCL-filter PWM rectifier (because the analysis is just for the battery charge mode of the BESS), delta connected and 100 kW. To test the closed-loop system, simulations including the battery model have been performed by using PSCAD/EMTDC.

Keywords: Battery Energy Storage System (BESS), Unbalanced grid conditions, PWM rectifier, Nonlinear control.
A Resonant DAB DC-DC Converter Using Dual Transformers With Wide Voltage Gain And Variable Switching Frequency

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A series resonant dual active bridge DC-DC converter using dual transformers with variable switching frequency is proposed in order to be used in wide input and wide output voltage range applications. ZVS conditions for the switches are discussed in detail by using fundamental component analysis. The control trajectory of ϕ and D is designed to realize wide range ZVS for switches. Nominal operating point is designed to reduce circulating current by changing switching frequency. The design of the turn ratios and the resonant tank selection have been demonstrated. A 1-kW prototype was built to verify the effectiveness of the control strategy within wide voltage gain range. Besides, the switches can achieve wide range ZVS turn-on. The maximum conversion efficiency can reach 95.15%. Keywords: Dual-Active-Bridge (DAB) converter, Series resonant, Wide-voltage-gain, Dual transformer, Zero-Voltage Switching (ZVS).

Multi Objective Optimal Control Method for T-Type Three-Level Inverter Based on Model Prediction

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In this paper, the main circuit mathematical model of T-type three-level inverter is established, and a multi-objective optimal control method of T-type three-level inverter model prediction is studied, which mainly includes output voltage control and neutral point potential balance control. Firstly, the load voltage and current are sampled, and the output voltage prediction value is calculated with the sample value, so that the error between the predicted voltage and the reference voltage is the most in the small switch state, the midpoint current of DC bus is measured at the same time, and the deviation value of midpoint potential is obtained. According to the charging and discharging conditions of corresponding DC side capacitor in this switch state, the switch state which reduces the deviation value of midpoint potential is optimized to act on the inverter in the next sampling period, so as to realize output voltage control and midpoint potential balance control. Finally, it is verified by Matlab / Simulink simulation and experiment. The simulation and experiment results show that the method can achieve the output voltage control and neutral point potential balance control well, and has the characteristics of simple principle and easy to digital realization.

Keywords: T-Type three-level, Multi-objective optimization, Model prediction, Voltage control, Neutral point potential balance.

A Novel Single-Phase Nine-Level Converter and Its Control Strategy

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Model predictive control (MPC) is a promising multilevel control method, has developed very well in recent years[1]. On the other hand, the MPC calculation amount is very large, and the need of calculation speed of the system is very high. In the three-phase three-level inverter, due to the weight factor, the calculation load is larger and the control is more complicated. This paper proposes a fast algorithm that does not require weighting factors and uses positive and negative small vectors to control the neutral point voltage, reducing 27 voltage vectors to 21 voltage vectors. This algorithm eliminates the calculation and debugging process of weight factors. Improved the portability of the algorithm. Simulation proves the effectiveness of the algorithm.

Keywords: Model prediction, Weight factor, Three-level, Value function.
A novel single-phase hybrid nine-level converter topology is proposed in this paper: the operation principles and one-dimensional space vector modulation strategy of the proposed topology are analyzed, and the integrated balance control strategy of the floating capacitor voltage and the proposed topology are analyzed, and the integrated balance one-dimensional space vector modulation strategy of the performance evaluation of the LC-L resonant converter with integrated magnetics is investigated. Through the equivalence relation of resonant tanks, the LLC resonant converter can be turned into the equivalent LC-L resonant converter. Though the LC-L resonant converter inherits almost all advantages of the LLC resonant converter, there exists some differences between them in the losses of magnetic components. The primary winding loss of the LC-L resonant converter is increased a bit, but the core and winding losses of the LC-L resonant inductor are reduced. Furthermore, in comparison with the LLC resonant converter, the LC-L resonant converter is more suitable for magnetic integration, because core losses of both the transformer and inductor can be reduced. A 700-kHz 430W/48V 400-W prototype is built to verify the theoretical analysis and evaluate the performance of the LC-L resonant converter with integrated magnetics.

Keywords: single-phase nine-level inverter, Voltage balance control, One-dimensional space vector modulation.

A Power Line Communication Method for SRG with Modified C-Dump Power Converter

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Switched reluctance generator (SRG) have unavoidable application potential in power generation because of good high reliability, simple structure, high fault tolerance, and therefore attract increasing research attentions. Due to the intelligentization demands, reliable communication is of great significance for fault monitoring and remote control among power converters integrated in microgrid systems.

In this paper, an improved new SRG power converter is discussed, which is able to reduce the number of switching devices, as well as the cost of SRG system. The power and signal synchronous transmission (PSST) is also realized by using the modified power converter without requirement of extra coupling equipment. The signals are embedded by modulating the output voltage ripples and FFT method is adopted on the receiver side to demodulate the signals. Simulation verification are carried out to confirm the feasibility of the proposed converter and power line communication method.

Keywords: Switched Reluctance Generators (SRGs), SRG power converter, Power and signal synchronous transmission, FFT.

A New Wideband Modeling Method of Converter Transformer

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In order to effectively calculate the electromagnetic transient characteristics of converter transformer, it is essential to master the impedance variation and resonance properties of converter transformers. This paper proposes a new segmented wideband modeling method for converter transformers from low frequency to high frequency. Firstly, the resistance parameters considering the skin effect of resistance and overvoltage faults, it is essential to master the capacitance between windings and the distributed capacitance to earth are measured by energy method. Then, the segmented wideband model of converter transformer is obtained by considering the dispersion characteristics of stray capacitances at high frequencies. Lastly, by comparing the simulation data with the measured data, the results show that the segmented wideband modeling method of converter transformer can effectively reflect the actual impedance variation and harmonic vibration characteristics of transformer in the fundamental frequency to megahertz band, and provide theoretical basis for the optimization design of converter transformer.

Keywords: Wideband modeling, Transformer, Stray capacitance, Leakage inductance.
Non-live Sessions

**P1160**
**An Improved Human-Simulated Intelligent Control Algorithm for Bidirectional DC-DC Converter**
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There are some limitations in the conventional algorithm of Human Simulated Intelligent Control (HSIC). It was neither accurately simulate the human control thought, nor adequately reflected the predictability of the system response characteristics, with under the behavior and function of multi-modes control as well as multi-objectives decision-making. On this basis, this paper proposed an improved Human Simulated Intelligent Control algorithm, according to the size of the error to choose the gain coefficient, it can improve the controller to predict the dynamic response of the system and to predict the trend so that the system more precision and fastness. Finally, a 3kW prototype is built and the simulation results and experimental results is conducted to verify the effectiveness of the proposed improved algorithm.

**Keywords:** Human simulated intelligent control algorithm, Matlab Simulink, Bidirectional DC-DC converter.

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**Session [TT23]**

**TT23: Power Electronics (VI)**

**P1249**
**Small-Signal Modeling of CLLC Bidirectional Resonant Converters**
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CLLC bi directional resonant converter inherits the advantages of high efficiency and high power density of LLC resonant converter, and has a symmetrical bidirectional voltage gain, which is suitable for applications where power flows in both directions. Based on the extended description function method, a small-signal model was established for the CLLC bidirectional resonant converter. The Bode plot was drawn by MATLAB based on the derived small-signal model. The validity of the model was verified by comparing the Bode plot obtained by analyzing the dynamic characteristics of the simulated circuit.

**Keywords:** Bidirectional DC/DC converter, CLLC resonant converter, Small-signal modeling, Extended describing function.

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**P1251**
**Analysis and Optimization of Single-Phase T-Type BCM Microinverter**
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This paper presents a detailed power loss model for a single-phase T-type boundary conduction mode (BCM) microinverter. And an optimized modulation strategy is proposed based on the established power loss model. This method uses dynamic reverse boundary current for control, and additionally realizes a zero-current switching (ZCS) of a switch, which further reduces the converter loss and improves power density. At the same time, the problem of output current distortion at the mode switching point under the fixed reverse current modulation strategy is improved. In addition, there is no need to add any auxiliary components to realize the optimized modulation strategy, and it can be realized only with a digital controller. At different power levels, the loss of the converter under two modulation strategies is analyzed using the established loss model, and the superiority of the proposed modulation strategy is verified. At the same time, it is verified through simulation that ZCS and zero voltage switching (ZVS) can be realized simultaneously in a certain range, and the output current waveform quality is further improved.

**Keywords:** Microinverters, Power loss analysis, Zero-Voltage Switching (ZVS), Zero Current Switching (ZCS), Boundary Conduction Mode (BCM), T-type.

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**P1268**
**Hybrid Modulation Interleaving Scheme for CRM Totem-Pole Bridgeless PFC Rectifier**
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This paper introduces the control method of the totem-pole bridgeless PFC rectifier working in the critical conduction mode (CRM), and analyzes the interleaving scheme based on this. Through analysis, we can get the scheme of interleaving with current-mode control and voltage-mode control. Under the waveform analysis, a hybrid modulation strategy with time periods is obtained, which is simple and reliable. It only needs to sample the input voltage and output voltage in real time to calculate the selection signal and the real-time switching cycle. The parameters of the main power circuit and the control module are designed by formula derivation. Finally, the feasibility of the scheme is verified by simulation. The ripple of the input current can be reduced, and the control scheme is simpler and more reliable.

**Keywords:** Critical Conduction Mode (CRM), Bridgeless PFC, Hybrid modulation strategy, Interleaving, Phase delay.
A Step-Up Switched Capacitor Multilevel Inverter with Reduced Switches Tolerating Lower Stress
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This paper presents a step-up switched capacitor multilevel inverter (SCMIL) containing small numbers of active switches, which will tolerate lower voltage stress. This topology allows low DC voltage to be converted into high AC voltage without DC boosting devices. The circuit’s operating states along with switching sequences are illustrated in detail. Afterward, a modulating strategy called Multi-carrier Sensesoidal Pulse Width Modulation (MC-SPWM) is introduced in order to yield a 4-level output voltage waveform. Finally, necessary simulations based on MATLAB/Simulink are carried out to verify the feasibility of the proposed topology and modulating strategy.

Keywords: Step-up, SCMIL, Active switches, Voltage stress, MC-SPWM, MATLAB simulation.

A Virtual Resistor Control Scheme for Boost Converter
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There are many control strategies for the boost converter, and a virtual resistor control scheme is introduced in this paper to improve its dynamic performance and stability. With consideration of nonlinearity, the state-space average model and the small-signal model of the boost converter are built and analyzed. Based on the small-signal model, the closed-loop control scheme with the virtual resistor is proposed to stabilize oscillation on the input DC bus and improve its stability. The theoretical analysis and essence are studied and illustrated. The impedance model with the control loop is calculated. Corresponding simulations are carried out to verify the feasibility of the proposed topology and modulating strategy.

Keywords: Boost converter, MPPT, Virtual resistor, Impedance model, Stability, Resonant peak.

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Excitation fault is troublesome because it takes a negative impact on the overall performance of the doubly salient electromagnetic machine (DSM). The output torque of DSM is only the reluctance torque when it operates in the state of loss of excitation. In order to make the motor operate normally in the state of loss of excitation, the motor parameters should be designed to meet the operation characteristics of DSM and SRM in the state of loss of excitation as much as possible. In this paper, the main structure factors that affect the normal operation of DSM in the state of loss of excitation were analyzed. Four modified structures were designed and simulated. The influence of the structural parameter changes on the electrical and magnetic characteristics of the motor was studied. The number of turns of DSM windings was optimized to achieve fault-tolerant operation was designed and simulated.

Keywords: Structural parameters, DSM, Finite element analysis, Excitation fault.
Finally, the operational results of the distributed economic optimization dispatch of the island MG are analyzed under the three different weather conditions, and simulation results demonstrate the effectiveness of the proposed model.

**Keywords:** Islanded microgrid, Economic optimization, Alternating direction multiplier method, Distributed optimization.

**P1282**

A Distributed Scheme for Economic Optimization Operation and Voltage Recovery with Constant Power Loads (CPLs) in DC Microgrids

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A fully distributed control scheme is proposed to simultaneously realize optimized economic operation of the DC microgrid with constant power loads (CPLs) and voltage recovery of DC bus. Considering CPL characteristics, an economic dispatch problem is solved to minimize the total generation cost based on consensus algorithm by controlling the output powers of the dispatchable sources. Therefore, unlike traditional centralized control, the distributed control adopted in this paper can greatly reduce the communication cost and speed up dynamic response when the network scale is large. Considering the limits of the generations, the consensus algorithm can achieve economic optimal operation without measuring load changes. On the other hand, average voltage observers are introduced to compensate the voltage drop caused by droop control. Simulation results based on MATLAB/Simulink verify effectiveness of the proposed method.

**Keywords:** DC microgrid, Consensus algorithm, Economic optimization, Voltage recovery, CPLs.

**P1422**

New Design and Implementation of Power Distribution Network Management System

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Due to the rapid development of the power grid, the number of power users has continued to increase, the scale and structure of the low-voltage distribution power system have become increasingly large and complex. Monolithic architecture systems can no longer handle complex applications, large amounts of data, and high concurrency. Therefore, we propose a new power distribution
network management system (DNMS) based on the framework called Spring Boot + SSM. The DNMS system uses a front-end and back-end separation method. The front-end uses a Bootstrap framework and the back-end uses a combination of Spring Boot + SSM framework. This improves the efficiency of system development and enhances the scalability and maintainability of the system. Functionally, a load forecasting model is built through the LSTM model, analyzing the state of the power system, then helping us to control the distribution network better and provide early warning and risk assessment. The users-transformer relationship module is based on the relationship between the base and the coordinates in the linear space by using big data technology to help us identify the relationship between households and transformers to realize, then make better management.

Keywords: Power distribution system, Distribution network management system, Data process, Relationship detection, Load forecasting.

P1111

Improved Delay-Based Phase-Locked Loop for Grid-Tied Inverter to Improve the Performance under Weak Grid

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In recent years, the grid-connected inverter and its control in the weak grid case have drawn wide attentions. For the grid synchronization, a phase-locked loop (PLL) is usually needed. Typically, the delay-based PLL is widely used in the single-phase application. However, when a large grid impedance exists at the point of common coupling (PCC) in the weak grid case, the inverter with the delay-based PLL cannot work well or even be unstable. Hence, this paper aims at proposing a robust method to improve the delay-based PLL performance with the large grid impedance. First, the system modelling is established. Then, an additional grid current feedforward is proposed to add into the delay-based PLL. It has been shown that the proposed method equivalently adds an adjustable impedance in series to the original inverter output impedance, and improves the behaviors in weak grid cases. The selection of parameters has been emphasized for maintaining the high robustness. At last, comparative waveforms have verified that the single-phase inverter with the proposed method can perform well even with the large grid impedance.

Keywords: Inverters, Phase-locked loops, Harmonic distortion, Robustness, Grid impedance.

P1496

Small-Signal Modeling and Comparative Analysis of Self Synchronous Droop Controlled Inverters in Microgrid System

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As for the droop controlled micro grid inverter based on self synchronization, the selection of the inner loop controller is critical. In order to analyze and compare the performance of two types of inner loop controllers, single voltage loop and voltage&current double-loop, the modular modeling method is used to establish the high-order small-signal models of the micro-grid system based on the above two types of inner loop controllers separately. Thus, the sub-models are independent and easy to modify and expand. Based on the models, the similarities and differences of oscillation mode evolution, parameter adjustment range, dynamic response and damping characteristics of single to dual system are compared. Finally, the simulation results prove the correctness of the smallsignal model and the stability analysis.

Keywords: Droop control, Small-signal modeling, Stability analysis, Single voltage loop.

P1511

A Method for Calculating the Impedance of Three-phase Transformer in Photovoltaic Power Station Based on Power Loss

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In the new energy power generation system, the transformer impedance as part of the grid impedance will affect the stability of the system. In order to calculate the transformer impedance, considering that the existing methods rely on the transformer nameplate parameters and require offline detection, this paper proposes an on-line calculation method of transformer impedance based on power loss. This method considers the influence of transformer impedance on system power and establishes a transformer power loss model, based on which a fitting calculation method for transformer impedance is proposed. Finally, the effectiveness of the method is verified by a specific transformer simulation model in photovoltaic power station.
A Two-stage Model Predictive Control Strategy for Economical Operation of Microgrid
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Keywords: Transformer impedance, Power loss, Photovoltaic power station.

Microgrid consisting of distributed diesel generators, battery packs and distributed photovoltaics can provide effective power supply for residents in remote areas such as islands. However, due to fluctuations in load power consumption and distributed PV output, it needs to be effective. The operational control method adjusts the power distribution to achieve cost-effective operation of the system and reliable power supply. Therefore, this paper proposes a microgrid optimal operation control strategy based on two-stage model prediction method. The first two-stage builds an optimal control problem based on an effective prediction of the power of each component to achieve optimal distribution of electrical energy. In order to improve the robustness of the control strategy to the prediction error, the second two-stage further adjusts the power generation of the diesel generator by solving the boundary value problem. The case study shows the effectiveness of the proposed control strategy in terms of computational feasibility, accuracy, robustness and cost reduction.

Keywords: Distributed energy resources, Economical operation, Two-stage model predictive control, Microgrid.
Research for Micro Energy Pulse Power Supply Used by Combination Electro-discharge Machining
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Micro-EDM is based on the phenomenon of electrical corrosion during spark discharge between the tool electrode and the workpiece to remove excess metal for processing. It is a micromechanical manufacturing technology that can process any conductive material. It has become an important method for the precision processing of conductive materials in mesoscopic scale. But the processing efficiency is low for current technology and it is difficult to meet the high-efficiency processing requirements of micro-processing with a large number or multiple repetitive features. In order to solve this problem, a kind of combined electrical machining micro-energy pulse power supply that meets the process methods including micro-EDM machining, micro-electrolytic machining, and wire electrode grinding has been developed. The method of serial and parallel micro-EDM has been achieved with a variety of process methods in multiple workstations. At the same time, in order to further improve the efficiency of electromachining, the following technologies were studied and explored, including increasing the discharge frequency, adaptive control of the discharge gap and system control based on CAN bus communication. This article focuses on the overall design idea of the micro-energy pulsed power supply and the key technology implementation methods. Finally, the experiment was implemented for the fabrication of micro-group characteristic group holes and slow-wave structure in travelling-wave tube to verify the performance of the micro-energy pulsed power supply in terms of micro-group characteristic processing. Keywords: Combination Electro-discharge Machining, micro-energy pulse power supply, CAN bus, adaptive control.

P1244

Simulation Based Method to Characterize Parasitic Parameters in a Double Pulse Test System
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As the switching speed of power semiconductor devices increases gradually, the influence of parasitic parameters on the system electromagnetic compatibility increases significantly. The simulation based characterization of parasitic parameters is very important to predict their influence in power converters during the initial design phase. In this paper, parasitic parameters of the components in a double pulse test system are extracted in Q3D and validated with measurements. A comprehensive circuit co-simulation model is then developed to determine the major parasitic parameters that affect the switching voltage spikes and the common mode currents in the IGBT module. The proposed characterization procedure and co-simulation techniques can also be applied confidently to other complex power converters.

Keywords: Common Mode (CM) current, Double Pulse Test (DPT), Electromagnetic Interference (EMI), Laminated busbar.

P1583

Voltage Control of Bipolar DC Distribution Systems Considering the Characteristics of Constant Power Load: A Load-Side Solution
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Employing bipolar DC distribution systems introduces the possibility of unbalanced voltage. This increases voltage deviations and power losses at each node due to the presence of the neutral line current. This study proposes a method of mitigating unbalanced voltage caused by constant power loads (CPLs) through DC electric springs (DC-ESs). In the case of the small-signal analysis of CPLs, a linearized model is utilized. On this basis, the coupling relations between positive and negative pole voltages are analyzed. After DC-ESs are introduced, the positive and negative pole voltages and output voltages of DC-ESs are found to be closely related, thereby deteriorating the dynamic performance of the control system and increasing its complexity. Therefore, a feedforward decoupling block
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#### P1051

**Suppressing Output Fluctuation of Dynamic Wireless Charging System by Dual-Loop Control of Receiver-Side Boost Converter**

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Dynamic wireless charging (DWC) technology enables the electric vehicle (EV) to be charged while driving. However, output of a DWC system often suffers severe fluctuations which results from the driving effects. This paper focuses on output control methods of the receiver-side boost converter. It is found that direct output control brings obvious charging fluctuations because of its inherent limitation. Hence, dual-loop control is utilized to solve this problem. Simulation results indicate that dual-loop control achieves a magnitude attenuation of 16 dB on the audio susceptibility characteristic. The changing current fluctuations at an emulated driving speed of 108km/h, under dual-loop control and direct control, are 0.3A and 2A with 5A output reference, respectively. Experimental results show a great improvement on output fluctuation with the receiver-side control.

*Keywords:* Dynamic wireless charging, Electric vehicle, Output fluctuation, Receiver-side control.

#### P1238

**Fault-Tolerant Control and Its Transit Process for Three-Level NPC Inverter Fed Induction Motor System**

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The three-level neutral-point-clamped (3LNPC) inverters require more reliable control strategies due to the increasing demand for safe operation on a critical occasion. In this paper, a fault-tolerant strategy and its transit process are presented for the induction motor (IM) system fed by the 3LNPC inverters. The mixed logic dynamic model (MLD) is used to generate the three-phase stator current residuals. Then, the residual information is used to identify the fault leg. Based on the detection results, a fault-tolerant control strategy, which is achieved by reconfiguring the topology and changing the modulation strategy, is introduced to ensure continuous and stable operation. Moreover, the transition from fault detection to tolerant control process is analyzed for improving the control performance of the system. The results have verified that the detection time, unbalanced dc-link capacitor voltage, and system operation conditions have an effect on the system operation performance. The feasibility and effectiveness of the proposed control strategy are verified by simulation.

*Keywords:* Fault detection, Fault tolerant control, Transit process, 3LNPC inverter fed IM system.

#### P1291

**Modeling and Stability Analysis of Peak-Current-Mode-Controlled SIDO CCM Buck Converter**

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Dynamic phenomenon is a key factor limiting stability performance for peak-current-mode-controlled (PCMC) single-inductor dual-output (SIDO) Buck converter. The paper published before has established 1-D approximate discrete, and iterative model for PCM-controlled SIDO DC-DC converter, which has investigated dynamic phenomenon and stability with variation of main circuit parameters. However, the model is not adjust to investigate dynamic phenomenon and stability with variation of load parameter and control parameters. In this paper, the 5-D accurate discrete iterative map model of PCM controlled SIDO Buck converter in continuous conduction mode (CCM) is established. Based on this, the dynamic analysis is emphatically studied by bifurcation diagram. Then, the effects of control parameter on the stable range of load parameters are obtained. Finally, experimental results are carried out to verify theoretical analysis results.

*Keywords:* Single-Inductor Dual-Output (SIDO), PCM-controlled, Accurate discrete iterative map model, Dynamic phenomenon.

#### P1304

**Optical Method Based Detection and Wavelets Based Processing of Acoustic Waves**

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Diagram is introduced based on the small-signal model analysis of DC-ESs in a single node of the bipolar DC system. This can greatly enhance the rapidity and anti-interference performances of the control system. Simulation and experimental results of the unbalanced-voltage suppression in the bipolar DC system are used to verify the effectiveness of the proposed scheme.

*Keywords:* Bipolar DC distribution systems, Voltage control, DC electric spring, Unbalanced DC load.
Acoustic waves (AW) have been used for the testing of static and dynamic structures. They contain the signature about the performance of rotary machines such as cyclic fatigue, friction, turbulence and cavitation. Thus has been extensively used in the condition monitoring and material characterization. In this paper, we present an algorithm based on wavelets to process the transient AW in time and frequency domain both simultaneously to extract its the temporal (e.g. time duration) and spectral properties (e.g. emission frequency). Further, optical method based on optical feedback (OF) is presented for detection of AW providing powerful non-contact, non-destructive diagnostic capabilities, which is safe, efficient, cost-effective and potential to be used in harsh conditions.

Keywords: Wavelets, Optical feedback, Acoustic waves, Condition monitoring.

Session [TT27] TI27: Signal and Information Processing (I)

P1057

Construction of Accurate Three-dimensional Cell Morphology Models from Confocal Images by Correcting Refractive Index Mismatch

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The light scattering is expected to provide a sensitive approach for non-invasive and label-free detection and classification of cells. Constructing accurate cell morphology models plays an important role in studying the relationship between light scattering and cell morphology. Currently, stacks of images obtained by laser scanning confocal microscopy (LSCM) are used to construct three-dimensional (3D) morphology of cells. However, the actual scanning distance of the confocal microscope is not equal to the scanning step size because the refractive index of the lens immersion medium and the sample medium do not match, which caused the constructed cell model to be stretched. In order to solve this problem, the relationship between the equivalent focus position (EFP) and the nominal focus position (NFP) is calculated by using a ray-tracing model. A correction factor is calculated, which can be used to correct refractive index mismatch. The confocal images are reconstructed by using Duke standard polystyrene spheres, and the constructed model are more like spheres, with little deviation between the confocal scanning direction and the nominal diameter.

Finally, a more accurate Jurkat T cell model is reconstructed, which can be used in the subsequent LSP inversion study.

Keywords: Label-free, 3D morphology of cells, Laser Scanning Confocal Microscope (LSCM), Refractive index mismatch, Jurkat T cell.

P1469

Multi-Scale Ship Tracking Based On Maritime Monitoring Platform

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With the development of computer processing, network communication and other modern technology and equipment, the management of ships on the sea surface is becoming increasingly intelligent and automated. It is very important for navigation safety to obtain the behavior trajectory of the target ship. In this paper, a ship tracking method based on twin-neural network is proposed, which is mainly aimed at the deformation, blurring and blocking of ship movement at sea. The complex target ship in Marine environment around the real-time accurate detection of trace. In this research emphasis, in this paper, the ship tracking module based on correlation filtering method is firstly used to track the target ship, and then use the peak response than for water mist, and other objects objects shade to what lead to the loss of the early warning, lost ship call based on the
In this paper, we present a detection method of sleeper defects based on the improved YOLO V3 algorithm to solve the shortcomings of the current track line maintenance which mainly is implemented by manual inspection, such as low efficiency and high risk factor. According to the characteristics of the background in the collected sleeper images, we optimize the weight value of the loss function. The k-means algorithm is used for clustering analysis of the sleeper data set, and then the optimal five sets of anchor box sizes are selected by the elbow method. For the purpose of improving the robustness of the model to different resolution images, we also adopt multi-scale training. The results of the experiment indicate that the improved YOLO V3 algorithm has obvious enhancement in the three performance indexes of Recall, Precision and mean Average Precision (mAP). Our work involving studies of intelligent identification of sleeper defects prove to be encouraging.

Keywords: YOLO V3, Sleeper defect detection, Loss function, K-means, Multi-scale training.
Scattering signals in microfluidics are widely used to detect cells by label-free method. However, it is hard to acquire the accurate scattering signals due to the different motion state when the cells passing through the detection area. In this paper, a dual-channel was designed to acquire the forward small-angle scattering signals which carries lots of biological information and quasi-Bessel beam was chosen as illumination source. Through the method of dual-channel acquisition, scattering signals in two angles can be detected simultaneously. This method has a great improvement in detection accuracy and the efficiency of obtaining biological information.

Keywords: Quasi-Bessel beam, Microfluidic chip, Scattering detection, Label-free, Dual-channel.

Study on Soft Sensing Technology of Penicillin Fermentation Based on PLS and SVR
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Penicillin fermentation process is highly nonlinear, timevarying and uncertain. Parameters such as key biological substrate concentration, cell concentration, product concentration of penicillin fermentation process are difficult to real-time measured on-line. Offline measuring method has time delay, and it is difficult to realize real-time control in the fermentation process. In order to solve the problem, a soft measuring method combined with partial least squares (PLS) and support vector regression (SVR) is put forward. First of all, the principal components were extracted from input data space by PLS, and then the SVR algorithm was used to establish the soft sensor model which can accurately predict the important parameters of penicillin fermentation process. The experimental results shown that compared with the traditional modeling methods, the measuring accuracy of PLS-SVR soft measurement model has good tracking performance and strong generalization.

Keywords: Deep learning, Generating Antagonism Network (GAN), Label-free, Hemocyte morphology, Phase recovery.

A Dual-Channel Design in Microfluidic Chip for Label-Free Detection by Quasi-Bessel Beam
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Scattering signals in microfluidics are widely used to detect cells by label-free method. However, it is hard to acquire the accurate scattering signals due to the different motion state when the cells passing through the detection area. In this paper, a dual-channel was designed to acquire the forward small-angle scattering signals which carries lots of biological information and quasi-Bessel beam was chosen as illumination source. Through the method of dual-channel acquisition, scattering signals in two angles can be detected simultaneously. This method has a great improvement in detection accuracy and the efficiency of obtaining biological information.

Keywords: Quasi-Bessel beam, Microfluidic chip, Scattering detection, Label-free, Dual-channel.

High Precision Phase Recovery for Single Frame Fringe Pattern of Label-free Cells Detection Based on Deep Learning
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As the basic unit of organism composition and life activity, the change of physiological state of cell is important to clinical disease prediction and diagnosis, especially blood diseases. In order to obtain the morphology of blood cells with abundant information content in 3D space without any biochemical or other complex processing for samples, this study proposed a transverse shear interference 3D imaging detection method for real-time dynamic label-free living cells based on deep learning. The phase extraction and recovery method of single red blood cell interference fringe image obtained by quantitative phase imaging system is carried out by Generating Antagonism Network (GAN).

This method has a great improvement in efficiency and accuracy, if has a profound impact on the study of biological cells, and can be extended to the fields of cancer diagnosis and drug development in genomics.

Keywords: 3D sensor, Optimal placement, Occlusion, CUDA.
A Detection Model for Anomaly on ADS-B Data
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Due to the influence of complex and changeable topographic structures, meteorological conditions and other factors, there are many errors between the actual flight track and ADS-B data received. In order to attain the accurate data track from ADS-B equipment in general aviation, there is a series of operation to move the abnormal data in the paper. First, in order to reduce the computational complexity of the model, the constraints are used for detecting the outliers which calculated by datasheet. In addition, in order to characterize the ADS-B data, the feature extraction was used by the setting window. After the operations for the collected ADS-B data, the unobvious anomalies were detected by the seq2seq model which based on LSTM. The experimental results demonstrate that the performance of this model is better than that of the traditional models.

Keywords: ADS-B, Anomaly data detection, seq2seq, Long Short-Term Memory (LSTM).

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In the paper, the improved particleswarm-optimization (PSO)-based satellite selection algorithm was proposed, which aims to improve the speed of satellite selection while ensuring positioning accuracy under the multi-constellation global-navigation-satellite-systems (GNSS) operational scenario. The results show that the proposed algorithm can improve the speed of selecting satellites, the selected satellite subset can ensure positioning accuracy and replace all-in-view satellites. Meanwhile, the proposed algorithm provides reference value for the multi-constellation integrated navigation satellite selection algorithm.

Keywords: Multi-constellation, Global Navigation Satellite Systems (GNSS), Satellite selection, Particle swarm optimization.
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**P1437**
System Identification of Static Nonlinear Elements: A Unified Approach of Active Learning, Over-Fit Avoidance, and Model Structure Determination
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Systems containing linear first-order dynamics and static nonlinear elements (i.e., nonlinear elements whose outputs depend only on the present value of inputs) are often encountered; for example, certain automobile engine subsystems. Therefore, system identification of static nonlinear elements becomes a crucial component that underpins the success of the overall identification of such dynamical systems. In relation to identifying such systems, we are often required to identify models in differential equation form, and consequently, we are required to describe static nonlinear elements in the form of functions in time domain. Identification of such functions describing static elements is often a black-box identification exercise; although the inputs and outputs are known, correct mathematical models describing the static nonlinear elements may be unknown. Therefore, with the aim of obtaining computationally efficient models, calibrating polynomial models for such static elements is often attempted. With that approach comes several issues, such as long time requirements to collect adequate amounts of measurements to calibrate models, having to test different models to pick the best one, and having to avoid models over-fitting to noisy measurements. Given that premise, this paper proposes an approach to tackle some of those issues. The approach involves collecting measurements based on an uncertainty-driven Active Learning scheme to reduce time spent on measurements, and simultaneously fitting smooth models using Gaussian Process (GP) regression to avoid over-fitting, and subsequently picking best fitting polynomial models using GP-regressed smooth models. The principles for the single-input-single-output (SISO) static nonlinear element case are demonstrated in this paper through simulation. Those principles can easily be extended to MISO systems.

**Keywords:** Active learning, Gaussian process, Nonlinear systems, Over-fitting, System identification, Uncertainty.

**P1621**
Safety Distance of Facilities and Personnel in Shale Gas Production Wellsite
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Shale gas is usually a high-purity methane gas and its content can reach up to 98% - 99%, and shale gas well has low production and low wellhead pressure; therefore, jet fire and vapor cloud explosion are very typical accidents after shale gas wells leakage. We use computational fluid dynamics PHAST Software to simulate the consequences of wellhead shale gas leakage fire and explosion under different gas production, wellhead pressure, wind speed and atmospheric stability. We can determine the safety distance of facilities and personnel on the gas production well sites with the thermal radiation and shock wave overpressure damage industry standards for equipment and human body. When the shale gas production is from $4 \times 10^3 \text{m}^3/\text{d}$ to $20 \times 10^3 \text{m}^3/\text{d}$ and the wellhead pressure is from 2Mpa to 4.61Mpa, the safe distance between the facilities and the wellhead is 23.2m, and the safe distance between the personnel and the wellhead is 58.9m. These findings are very important to optimize well site layout and to ensure personnel safety, which can achieve safe and efficient exploitation of shale gas.

**Keywords:** Shale Gas, Computational fluid dynamic, Jet fire, Explosion, Safety distance.

**P1029**
Signal Processing Techniques for Nonlinear Identification of Structures Using Transient Response
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In this work, an alternate method for the nonlinear system identification of vibrating structures is investigated. This method makes use of transient vibrations in combination with advanced signal processing techniques to determine hardening or softening effects and strength of nonlinearity. In order to demonstrate this method’s practicality and how transient vibrations can be used to determine nonlinearity, an experiment involving a cantilever beam has been subjected to vibratory analysis. Furthermore, a novel signal tracking technique, known as the Harmonics Tracking Method, has been used in conjunction with experimental data for signal analysis and compared to another widely known signal processing tool called the Hilbert-
In view of the problem that the balance rate of pumping unit needs to be tested frequently in the oil field, the accuracy of conventional current method is insufficient, a portable balance rate tester of pumping unit based on ADE7755 and acceleration sensor is developed in this paper. Firstly, the basic principle and overall structure of the balance rate tester of pumping unit using electric energy method are introduced, and principle of the acceleration sensor and wireless communication technology are analyzes the working, the acceleration sensor circuit and the flow chart of the system software. At last, the balance rate tester was used in Shengli oilfield. The field results show that the balance instrument is portable, easy to operate and accurate. It is recognized by the field staff and can provide accurate balance rate reference for the pumping unit.

Keywords: Balance rate, ADE7755, Electric energy, Acceleration sensor.

Detection of Major Depressive Disorder using Signal Processing and Machine Learning Approaches
Shahriar Saleque1, Gul-A-Zannat Spriha2, MD Rasheeq Ishraq Kama3, Rafia Tabassum Khan4, Amitabha Chakraborty5 and Mohammad Zavid Parvez5
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In modern warfare, possessing advanced electronic warfare technology and equipment can occupy a dominant position in the war and greatly improve the victory rate. Radar emitter signal recognition is a key technology in electronic countermeasures. How to quickly and accurately recognize radar emitter signals is an urgent problem to be solved in electronic countermeasures. In this paper, A radar emitter signal sorting method is proposed to solve the problem of low success rate of radar emitter signal sorting in complex electromagnetic environment, the radar emitter signal sorting can be completed quickly and efficiently by judging the degree of radar emitter signal aliasing, reorganizing the sample sequence, and adopting fast density clustering sorting to process the carrier frequency and pulse width two sorting characteristics. It has certain practical value in the field of radar emitter signal sorting.

Keywords: Density clustering, Pulse description word, Discrimination of aliasing, Radar emitter signal sorting.

Image Reconstruction using RAPID Algorithm with Time-Frequency Analysis
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The detection of cracks is crucial in some industries, such as petroleum and aerospace. In order to detect these cracks,
a modification to the Reconstruction Algorithm for Probabilistic Inspection Damage (RAPID) has been proposed. This modification consists of comparing the time-frequency content of the signals instead of only analysing their waveforms. This analysis has been performed over the usual analysis, such as filtering the signal and observing the behaviour of defects with different frequencies. The results of this experiment show the ability of this approach to localize defects agreeing with the real position of the defect. However, the shape detection of this approach needs to be improved. Nevertheless, the modification presented in this paper shows great potential and with further work it is possible to obtain better results.

Keywords: Frequency-domain analysis, Nondestructive testing, Time-domain analysis, Ultrasonic imaging.

P1553

Denoising Method for Ultrasonic Flaw Echo Based on EMD and Local Entropy
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Aiming at the challenge of eliminating structural noise and electronic noise in ultrasonic nondestructive testing when detecting metallic materials, a denoising method combining empirical mode decomposition (EMD) with local entropy is proposed for flaw echo denoising. In this method, the Intrinsic Mode Functions (IMFs) components and residual components of ultrasonic signal were obtained through the EMD. A Similarity Measure method was used to select the signal dominant modes. Then, the local entropy of the first signal dominant mode was calculated to identify the location of defect echoes, and a window was used to preserved defect echoes in the all relevant modes. Finally, the signals after denoising was obtained by accumulating defect echoes and residual components. Denoising results of simulative signal and experimental data show that the presented method can significantly remove noise from ultrasonic detecting signal and keep the flaw echo to the maximum extent.

Keywords: Signal denoising, Ultrasonic flaw echo, Empirical Mode decomposition, Local entropy.

P1562

Research on Vehicle Logistics Terminal Design
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With the current rapid development and expansion of the domestic automobile industry, it puts higher requirements on the logistics companies for safety, efficiency, and cost-effectiveness during logistics transportation. A vehicle monitoring terminal system based on the Internet of Things technology is designed in this paper, which is mainly composed of power supply module, core control module, peripheral interface module, communication module, positioning module, and liquid crystal display (LCD) module. The hardware of the main modules is designed and analyzed in detail. The test results show that the hardware modules of the system are designed reasonably and can meet the expected functional requirements and design indicators.

Keywords: Vehicle monitoring terminal, Smart logistics, Internet of things, LCD display.

P1364

Design and Implementation of the Anti-Noise High Precision Voltage/Current Data Acquisition System
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Aiming at the problems of low precision and big fluctuation of voltage and current data acquisition in the process of inertial navigation system, in this paper, an anti-noise high precision data acquisition, and processing system has been designed and implemented based on AD7176-2 and STM32. The acquisition system mainly includes signal isolation circuit, external excitation circuit, front analog amplifier circuit, AD conversion circuit, and software platform. The 24-bit high precision AD converter with an external voltage reference source converts the analog voltage and current signal output by the current source to the digital signal. The digital signal is filtered by the internal filter of ADC and the anti-pulse interference digital filter, then it is processed and transmitted to the host computer through the embedded microprocessor. After a series of experiments and tests, the detailed experimental data and results show that the data acquisition system can operate continuously and stably with very low noise, high precision and large dynamic range.

Keywords: AD converter, Low noise, High precision, Data acquisition.

P1119

Global Optimization based on Mixed H2 and Hinf Approach for Placement of Piezoelectric Actuators and Sensors on Curved Surfaces in Actively Controlled Structures
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ICIEA 2020 — Abstracts
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Session [TT31] TT31: Network and Communication Technologies

P1153

On the Impact of Static and Mobile Wormhole Attacks on the Performance of MANETs with AODV and OLSR Routing Protocols

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The presence of actuators and sensors characterizes inevitably all operating processes in engineering, industry or applied research. Careful selection of the actuatorsensor placement can substantially improve performance of systems and contribute in turn to considerable savings. With respect to suppression of unwanted vibrations in lightweight structures by applying appropriate control, piezoelectric films represent convenient solution since they can be easily integrated with structures and due to their lightweight character they do not influence the overall mass of structures, but may contribute to changing stiffness in accordance with applied control and in that way actively perform adapting the structure’s properties to changing environmental conditions. In this paper a global optimization procedure for placement of piezoelectric actuators and sensors on lightweight structures prone to vibration is presented. Optimization is model-based and assumes software-in-the-loop coupling of finite element numeric software with corresponding programming solutions to provide iterative exploration of a predefined set of candidate locations with respect to defined objective functions. The objective here is defined in terms of $H_2$ and $H_{\infty}$ norms constructed upon the eigenfunctions of structures, which provides maximization of the control influence or maximal sensing effect. Implementation is illustrated by two examples of structures with curved surfaces – cylindrical and funnel shaped structure.

Keywords: Optimization, $H_2$ and $H_{\infty}$ norm, Actuator and sensor placement, Piezoelectric smart structures.

P1167

Novel Fault-Tolerant Routing Technique for ZMesh Topology based Network-on-Chip Design

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This paper proposes a novel fault-tolerant routing technique for ZMesh topology based Network-on-Chip (NoC) design. The proposed algorithm caters the link faults and routes the data packets seamlessly to the destination. The experiments have been carried out by increasing ZMesh network size and percentage of link faults. The results show that in the event of link failures the proposed algorithm routes the data from source to destination flawlessly.

Keywords: Network-on-Chip, ZMesh, Fault tolerance, Routing algorithm, Link faults.

P1157

On the Impact of Static and Mobile Wormhole Attacks on the Performance of MANETs with AODV and OLSR Routing Protocols

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Mobile Ad hoc Networks (MANETs) consist of mobile autonomous nodes that rely on each other to forward the traffic. This cooperative nature may be exploited by attackers to accomplish malicious goals such as disrupting the traffic flow. One such type of attack is the wormhole attack where two colluding malicious nodes capture the traffic from one part of the network and forward it to another part via a tunnel. The malicious nodes could then drop or manipulate the packets passing through the tunnel.

In this paper, we investigate the impact of two types of wormhole attack on MANET performance: static wormhole where the malicious nodes are static, and mobile wormhole attack where the malicious nodes are mobile. We analyze the impact on two routing protocols: On-Demand Distance Vector (AODV) and Optimized Link State Routing (OLSR).

The results show that the OLSR proactive routing protocol behaves much better under wormhole attacks than the AODV routing protocol. The drop in the packet delivery ratio and throughput under the wormhole attack for AODV is 50-65% while it is 10-12% in the case of OLSR.

Keywords: MANET, Wormhole, AODV, OLSR, Simulation.
net pages are automatically designed and generated by computers. After being generated, effective evaluation mechanisms are needed for verification and feedback. At present, the evaluation model of visual design generally takes traditional web pages as the research object, and there is little research on the complexity and marketing characteristics of e-commerce information. It is necessary to consider how visual design can promote the effectiveness of communication between users and web pages from the perspectives of psychology, behavior and content. This paper proposes a “multi-dimensional visual performance evaluation model” for the evaluation after the generation of contemporary ecommerce web page design. This paper first constructs the visual marketing system and discusses the circulation mechanism of user demand import, e-commerce web page design, multi-dimensional visual performance evaluation and visual precision marketing. Under the system, a relational model of how “visual performance indicators (aesthetic performance, search behavior performance, information usefulness performance)” based on “scene factors” affect “overall evaluation” is proposed, defined as a multidimensional visual performance evaluation model, and verified by quantitative experiments. The model provides visual design basis for designers and recyclable evaluation data for machine learning generated pages.

Keywords: E-commerce web page, User experience, Visual performance, Satisfaction.

A Comparative Study of Energy-Aware Routing of Wireless IoT for Intelligent Gas Metering
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IoT for intelligent gas metering have the characteristics of wide coverage and large capacity, in which data relay nodes and intelligent gas meters are powered by battery with limited energy. Aiming at the above characteristics, this paper proposes a distributed energy-aware routing algorithm of wireless IoT for intelligent gas metering (DEAR-IoT) to balance the node energy consumption and prolong the network lifetime. However, when using this algorithm in wireless IoT for intelligent gas metering, the topology of network model has a great influence on the performance of the proposed algorithm. Accordingly, the performance analysis of DEAR-IoT running in different network models constructed by complex theory was presented in this paper. The simulation results and performance analysis will help the engineers to improve the topology of network model when using the proposed algorithm in wireless IoT for intelligent gas metering.

Keywords: IoT, Intelligent gas metering, Energy-aware routing, Network lifetime, Complex networks.
The part-based weighting aggregation (PWA) method is a simple and straightforward way for creating powerful image representations in image retrieval. In this paper we analyze the burstiness among the responses of the aggregated channels in the PWA method, and propose a channel-wise weights utilizing the sum-pooling aggregation of the deep features' responses to regulate the burstiness among the feature maps. Firstly, we apply the channel weights to the aggregation stage of PWA. The regulation of the burstiness among the aggregated channels boosts the PWA performance. Secondly, we use the channel weights to the part selection stage, namely, selecting the part detectors based on the channel weighted feature maps to obtain more discriminate parts to further improve the PWA performance. Comprehensive experiments on four standard datasets have demonstrated the effects of the proposed method.

Keywords: Image retrieval, Deep convolution feature aggregation, Visual burst phenomenon, Channel weight.

P1186
Improving Black Box Classification Model Veracity for Electronics Anomaly Detection
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Data driven classification models are useful to assess quality of manufactured electronics. Because decisions are taken based on the models, their veracity is relevant, covering aspects such as accuracy, transparency and clarity. The proposed BBStepwise algorithm aims to improve the classification model transparency and accuracy of black box models. K-Nearest Neighbours (KNN) is a black box model which is easy to implement and has achieved good classification performance in different applications. In this paper KNN-Stepwise is illustrated for fault detection of electronics devices. The results achieved shows that the proposed algorithm was able to improve the accuracy, veracity and transparency of KNN models and achieve higher transparency and clarity, and at least similar accuracy than when using Decision Tree models.

Keywords: Black box, Classification, Veracity, Feature Selection, Knn, Stepwise.

P1634
A Cognitive Analytics based Approach for Machine Health Monitoring, Anomaly Detection, and Predictive Maintenance
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Traditionally, there are two major limitations for machine learning (ML) assisted manufacturing applications. First, it would require a tremendous amount of manual data annotations for ML models. Second, ML models are often learned offline and unable to capture the machine dynamism and adapt to changes over the time. In this paper, we propose a framework based on the concept of cognitive analytics with unsupervised learning for machine health monitoring, anomaly detection and predictive maintenance. The experi-
Indoor Space Classification Using Cascaded LSTM
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Indoor space classification is an important part of localization that helps in precise location extraction, which has been extensively utilized in industrial and domestic domain. There are various approaches that employ Bluetooth Low Energy (BLE), Wi-Fi, magnetic field, object detection, and Ultra Wide Band (UWB) for indoor space classification purposes. Many of the existing approaches need extensive pre-installed infrastructure, making the cost higher to obtain reasonable accuracy. Therefore, improvements are still required to increase the accuracy with minimum requirements of infrastructure. In this paper, we propose an approach to classify the indoor space using geomagnetic field (GMF) and radio signal strength (RSS) as the identity. The indoor space is an open big test bed divided into different indiscernible subspace. We collect GMF and RSS at each subspace and classify it using cascaded Long Short Term Memory (LSTM). The experimental results show that the accuracy is significantly improved when GMF and RSS are combined to make distinct features. In addition, we compare the performance of the proposed model with the state-of-the-art machine learning methods.

Keywords: Geomagnetic field, Radio signal strength, LSTM, Deep recurrent neural network.

Deep Learning Based Binary Classification for Alzheimer’s Disease Detection using Brain MRI Images
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Alzheimer’s disease is an irremediable, continuous brain disorder that gradually destroys memory and thinking skills and, eventually, the ability to carry out the simplest tasks. It has become one of the critical diseases throughout the world. Moreover, there is no remedy for Alzheimer’s disease. Machine learning techniques, especially deep learning-based Convolutional Neural Network (CNN), are used to improve the process for the detection of Alzheimer’s disease. In recent days, CNN has achieved major success in MRI image analysis and biomedical research. A lot of research has been carried out for the detection of Alzheimer’s disease based on brain MRI images using CNN. However, one of the fundamental limitations is that proper comparison between a proposed CNN model and pre-trained CNN models (InceptionV3, Xception, MobileNetV2, VGG) was not established. Therefore, in this paper, we present a model based on 12-layer CNN for binary classification and detection of Alzheimer’s disease using brain MRI data. The performance of the proposed model is compared with some existing CNN models in terms of accuracy, precision, recall, F1 score, and ROC curve.

Keywords: Alzheimer, Machine learning, Deep learning, CNN, MRI, OASIS-1, Confusion matrix, Accuracy, ROC curve.

Grapheme to Phoneme Conversion of Norwegian using Hidden Markov Models
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In this paper, the applicability of Hidden Markov Models to the grapheme-to-phoneme (GTP) problem of Norwegian is explored. The grapheme-to-phoneme problem, is part of the problem of converging sequences of graphemes to sequences of phonemes. This is an important issue in both text-to-speech and speech recognition systems. With the assistance of established toolkits like CMU-Cambridge Language Modeling Toolkit and Hidden Markov Model Toolkit (HTK), an approach based on Hidden Markov Models (HMM) is presented and implemented. By such an approach every phoneme is modeled by an HMM that generates the graphemes. This approach has previously been tested on English data. By using HMM for Norwegian, a phoneme accuracy of 94%, and a word accuracy of 68% is obtained. This is slightly better than similar results obtained for English.

Keywords: Hidden Markovian Models (HMM), N-gram modelling, Grapheme-to-Phoneme conversion, Corpus of Norwegian transcriptions.
### Non-live Sessions

**Session [TT33]**

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<tr>
<td>P1452</td>
<td>Research on Fault Diagnosis of Flight Control System Based on SVM Optimization</td>
<td>Jing Lu Du, Zhiguang Wang, and Qiang Zhou</td>
<td>School of Automation Science and Electrical Engineering, Beihang University, Beijing, China. E-mail: <a href="mailto:gtny09@163.com">gtny09@163.com</a>, 3136015696163.com, 136311037896133.com</td>
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This paper designs a fault diagnosis model based on the SVM algorithm. The data is obtained through simulation and preprocessed to obtain training data. Then, based on the SVM multi-class model, different kernel functions are used for analysis, and various types of kernel functions are analyzed and compared. After that, the advantages of the Adaboost classification algorithm were analyzed, and the advantages of the SVM classification algorithm were complementary. A hybrid model of SVM/Adaboost fault diagnosis was proposed, and simulation experiments were performed on the obtained model. It is confirmed that the model does improve the accuracy of fault diagnosis.

Keywords: Fault diagnosis, SVM, Adaboost.

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<tr>
<td>P1556</td>
<td>Transfer Learning in General Lensless Imaging through Scattering Media</td>
<td>Yukuan Yang, Lei Deng, Peng Jiao, and Yansong Chua</td>
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Recently, deep neural networks (DNNs) have been successfully introduced to the field of lensless imaging through scattering media. By solving an inverse problem in computational imaging, DNNs can overcome several shortcomings in the conventional lensless imaging through scattering media methods, namely, high cost, poor quality, complex control, and poor anti-interference. However, for training, a large number of training samples on various datasets have to be collected, with a DNN trained on one dataset generally performing poorly for recovering images from another dataset. The underlying reason is that lensless imaging through scattering media is a high-dimensional regression problem and it is difficult to obtain an analytical solution. In this work, transfer learning is proposed to address this issue. Our main idea is to train a DNN on a relatively complex dataset using a large number of training samples and fine-tune the last few layers using very few samples from other datasets. Instead of the thousands of samples required to train from scratch, transfer learning alleviates the problem of costly data acquisition. Specifically, considering the difference in sample sizes and similarity among datasets, we propose two DNN architectures, namely LISMU-FCN and LISMU-OCN, and a balance loss function designed for balancing smoothness and sharpness. LISMU-FCN, with much fewer parameters, can achieve imaging across similar datasets while LISMU-OCN can achieve imaging across significantly different datasets. What’s more, we establish a set of simulation algorithms that are close to the real experiments, and it is of great significance and practical value in the research on lensless imaging. In summary, this work provides a new solution for lensless imaging through scattering media using transfer learning in DNNs.

Keywords: Lensless Imaging through Scattering Media, Deep Neural Networks, Transfer Learning, Fine-tuning.

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**Paper ID**: P1182

**Title**: Acoustic Source Localization for Anti-UAV Based on Machine Learning in Wireless Sensor Networks

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Unmanned aerial vehicles (UAVs) have developed rapidly and are widely used in many fields. This phenomenon also causes security problems that urgently need to be addressed by anti-UAV techniques. The localization of UAVs plays an important role in anti-UAV systems. An acoustic source localization scheme based on machine learning (ML) in wireless sensor networks is proposed in this study. Five ML algorithms, namely, artificial neural network (ANN), Naive Bayes, decision tree (DT), K nearest neighbors (KNN) and random forest (RF), are designed to estimate the coordinates of a single UAV. The acoustic energy decay model is constructed to simulate the attenuation and distortion caused by the ambient noise and changing surroundings. We use both received signal strength (RSS) based on acoustic energy and the difference of RSS as the input. Our experiments show that ML algorithms perform well except ANN. For ambient noise case, the ones with the input we propose achieve better localization accuracy than those only using RSS. KNN and RF are more suitable and reliable models for localization.

Keywords: Acoustic source localization, Anti-UAV, Machine learning, Received signal strength, Wireless sensor networks.
P1211

Distant Supervision Relation Extraction Model Based on Feature-recalibration Networks
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Relation extraction (RE) is a crucial ingredient in numerous natural language processing tasks for mining structured facts from heterogeneous texts. This paper presents a novel neural network architecture called Feature-recalibration (FR) Networks, that adaptively recalibrates channel-wise feature responses by explicitly modelling interdependencies between channels. This architecture enables end to end learning from task-specific labeled data, forgoing the need for external knowledge such as explicit dependency structures and entity description information. Experimental results on the New York Times dataset demonstrate the effectiveness of our proposed model.

Keywords: Natural language processing, Deep learning, Distant supervision, Relation extraction, Feature-recalibration.

P1582

Hyper-Parameter Initialization for Squared Exponential Kernel-based Gaussian Process Regression
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Hyper-parameter optimization is an essential task in the use of machine learning techniques. Such optimizations are typically done starting with an initial guess provided to hyperparameter values followed by optimization (or minimization) of some cost function via gradient-based methods. The initial values become crucial since there is every chance for reaching local minimums in the cost functions being minimized, especially since gradient-based optimizing is done. Therefore, initializing hyper-parameters several times and repeating optimization to achieve the best solutions is usually attempted. Repetition of optimization can be computationally expensive when using techniques like Gaussian Process (GP) which has an O(n^3) complexity, and not having a formal strategy to initialize hyperparameter values is an additional challenge. In general, reinitialization of hyper-parameter values in the context of many machine learning techniques including GP has been done at random over the years, some recent developments have proposed some initialization strategies based on the optimization of some meta loss cost functions. To simplify this challenge of hyperparameter initialization, this paper introduces a data-dependent deterministic initialization technique. The specific case of the squared exponential kernel-based GP regression problem is focused on, and the proposed technique brings novelty by being deterministic as opposed to random initialization, and fast (due to the deterministic nature) as opposed to optimizing some form of meta cost function as done in some previous works. Although global suitability of this initialization technique is not proven in this paper, as a preliminary study the technique’s effectiveness is demonstrated via several synthetic as well as real data-based nonlinear regression examples, hinting that the technique may have the effectiveness for broader usage.

Keywords: Gaussian process, Hyper-parameters, Kernel, Machine learning, Nonlinear regression, Optimization, Squared exponential.

P1284

Automatic Solving of Stabilization System Synthesis Problem by the Network Operator Method
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The work is devoted to application of the network opera-
A Survey on Sensors for Autonomous Systems
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This paper presents a survey on state-of-the-art sensors for autonomous systems. The key performance parameters along with the operating principle of sensors used in autonomous systems are thoroughly explored. Practical aspects such as performance parameters, sensor output data format, sensor interfaces, size, power consumption, compatible hardware platforms, data analysis, and signal processing complexities are summarized. Such information serves as a practical guide for designing smart sensing systems for autonomous systems.

Keywords: Sensors, Ultrasound sensor, mmWave sensor, Thermal camera, mmWave Radar, LiDAR, Automotive camera, SLAM, Autonomous systems.
Research on Calculation Method of Line Loss in Distributed Transformer Area Considering Uncertainty of Distributed Photovoltaic Output
Rujia Qu1, Bo Gao1, Lizhu Pan2, Zhengkai Zhang2, Wei Fan2, Nan Zhang1 and Peigang Han3
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Distributed PV output is affected by actual factors such as season and weather, and its output has certain volatility. How to quantitatively analyze the impact of distributed PV access on distributed network loss is of great significance for improving the economic benefits of power companies. Firstly, based on the spectral clustering method, the PV output curves in different scenarios are constructed, which reduces the computational complexity and computational error caused by the fluctuation of distributed PV output. Secondly, the daily load curve of each phase user is constructed by using the current and voltage curves and the PV output curve of each phase at the outlet of the distributed transformer area. Then, using the typical daily load curve and PV output curve of each phase user, a theoretical line loss calculation method based on the forward and backward substitution method of the distributed transformer area with distributed PV is constructed. Finally, the feasibility of the proposed algorithm is verified by the actual transformer area, which provides a theoretical basis for the line loss optimization of the distributed transformer area with distributed PV.

Keywords: Spectral clustering, Photovoltaic output curve, Three phase outlet current, Theoretical line loss calculation.

Design and Application of a Photovoltaic-Energy Storage Joint System with Active Frequency Regulation Capability
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With the high proportion of photovoltaic power generation replacing traditional energy generation, the frequency regulation capability of the power system is weakened. How to improve the frequency regulation capability of the power system where distributed photovoltaic is densely accessed is an important factor to promote the consumption of new energy. To this end, this paper firstly proposes a structure of a photovoltaic combined energy storage unit to form a joint photovoltaic-energy storage system (PV-ES). Under the premise of not increasing the grid-connected inverter, the energy storage unit and the DC side of the photovoltaic inverter are controlled for power exchange, the frequency support is quickly provided when the grid power needs, and the state of charge (SOC) of the energy storage unit is managed. Then, the actual photovoltaic power station is selected and the active frequency control system is established. Finally, the effectiveness of the proposed scheme is verified by monitoring the charge and discharge of the energy storage unit under frequency disturbance.

Keywords: Primary frequency regulation, Photovoltaic power generation, Energy storage unit.

Measuring Analysis of Power Grid Cascading Failures Based on Data Mining Algorithm
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The defects of the present fault chain model of power grid cascading failures have been summarized and a defined method for forecasting cascading failures is presented based on a fault chain model and Fuzzy C-Means. First, in order to reduce the workload and overcome the limitation of present means, this method selects a number of lines with the high value of predictive index to be the next outage lines during fault chain forecasting. Then, this paper analyzes the correlations among lines. Finally, taking IEEE 39-bus system as example, the rationality of the method proposed is verified based on comparison with other means.

Keywords: Cascading failures, Blackout, Fault chain, Dynamic fault tree analysis, Importance analysis.
With the technological development of energy storage systems and their large-scale application in the power grid, it has become possible to use them as black-start power sources for the power grid. Compared with the traditional black-start recovery time, the black-start solution based on the energy storage system can achieve millisecond response, which is expected to greatly reduce the recovery time and reduce power loss after a power grid failure. By establishing a basic output model of the energy storage system and a 30-node power grid system model to configure the capacity of the energy storage system, and analyze the traditional grid black-start scheme and the scheme based on the energy storage system. Finally, the impact of different access points of the energy storage system in the power grid and the importance of the grid load on the black-start scheme is analyzed.

Keywords: Black-start power sources, Energy storage system, Capacity allocation, Mathematical model.

A Novel Adaptive Stabilization Strategy for Autonomous DC Microgrids
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In order to solve “over conservatism” and “limited stability margin” brought by the existing robust control strategies, this paper proposes a novel adaptive controller. By employing a finite-time feedforward decoupling procedure, variations of the internal parameters and external disturbances can be timely estimated and then compensated by the feedforward decoupling loops. In reference to existing related resolutions, a adaption measurement is introduced. By doing so, the system can online update the control gain according to operation conditions of DC microgrid system. Simulation results conducted in Matlab/Simulink verify the efficiency of the proposed control strategy.

Keywords: DC microgrid, Largo-signal stability, Decentralized control, Adaptive control, Renewable energy sources, Constant power load.

Optimal Modeling of Integrated Energy Demand Response under Time-Shared Electricity Price
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With the rapid development of environmental technologies such as renewable energy, smart grid, and electric vehicle transportation, future power generation and power supply will show new features. The design of energy consumption characteristics of modern power system is more flexible and easy to control, which will also affect the scale of power generation system. This paper presents a combined capacity optimization method for a typical independent microgrid including solar photovoltaic, wind turbines, diesel generators and battery energy storage system. The mathematical models of photovoltaic, wind turbines, diesel generation system, battery energy storage system and electric vehicle charging loads are developed to improve the capacity opti-
Control Strategy for Fast Frequency Modulation of Regional Power Grid with Energy Storage System

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For renewable energy sources such as photovoltaics and wind power gradually increase in the power system, the proportion of conventional synchronous generators has gradually decreased, and the system's primary frequency modulation capacity has weakened. The energy storage system has the advantage of fast active power response, which can effectively improve the dynamic frequency response characteristics of the system. According to its advantages, this paper proposes a fast frequency modulation method for energy storage systems. First, an equivalent model of the regional power grid where the energy storage system participates in primary frequency modulation is established. On this basis, amplitude-frequency characteristics are analyzed. Then, the PADE method is used to simplify the model, and the control parameters are calculated by simplifying the model. In addition, use the root-locus method to verify the control parameters. Finally, the effectiveness of the proposed fast frequency modulation control method for energy storage system is verified by the simulation results.

Lyapunov Based Current Control Scheme for Grid-Connected Inverter

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A novel current controlled scheme based on Lyapunov function has been proposed for the grid-connected inverter. only one control parameter need to be tuned in the proposed Lyapunov based controller, compared to the traditional proportional-integral controller. A simple control structure in proposed method is easy to be implemented and the designed controller can track the current reference quickly. Moreover, the injected current can still have a satisfied total rated-current distortion when connected to a distorted grid. The steady state and dynamic performance of the proposed control scheme has been validated by the comparative simulation results.

Distributed Nonconvex Economic Dispatch Algorithm for Large-Scale Power System

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This paper proposes a distributed genetic algorithm to solve the non-convex optimal power allocation problem in large-scale power system. Such problem is usually solved by some heuristic search methods such as genetic algorithm (GA). It is noted that traditional genetic algorithms are usually centralized, and their genetic operators are directly operated on the entire combined solution by a single control center. When considered system scales up, its computational cost would be tremendously high. In order to overcome this problem, in this paper we aim to revise the GA algorithm to be implemented in a fully distributed way. The main idea of the proposed distributed GA is to treat the power output solution of a single distributed generator as an individual, and each local agent has a separate population and performs genetic operations independently. The fitness information used for the crossover comes from the average consensus of the local fitness. The power outputs of the entire generator set is considered as the combined individual, which are found to converge near the optimal solution in the formulation experiment At the end of the paper, a case study on 10 generator units shows that the distributed genetic algorithm is capable to solve nonconvex economic dispatch (ED) problem while perfectly fitting the distributed framework in most scenarios.

Keywords: Distributed genetic algorithm, Non-convex optimization problem, Average consensus, Economic dispatch, Power system.
In designing the coordinated controller, the adaptive estimation law of damping coefficient is designed by adopting immersion and invariant (I&I) adaptive control method, and the control law of STATCOM is designed based on backstepping method, and the generator excitation control law is obtained by combining passivity theory. For overcoming the “explosion of complexity” problem, a nonlinear damping algorithm is introduced to deal with the uncertainties, which consists of the influence of external disturbance and virtual control. The simulation results show that the designed coordinated controller effectively improves the stability of the power system and has strong adaptability and robustness.

Keywords: Excitation control, STATCOM, Immersion and invariant adaptive control, Backstepping, Nonlinear damping algorithm.

P1322

High-efficiency Oriented Control Method of Bidirectional CLLC Resonant DC/DC Converter for Energy Storage System

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In small-scale hybrid AC/DC microgrid for residential applications, the CLLC-type resonant DC Transformer (DCT) is widely used because of its advantages of bidirectional power flow, electrical isolation, high efficiency, low cost and soft switching. However, single CLLC resonant converter has only one fixed output voltage, which makes it difficult to be compatible with most household appliances. In this paper, three-port resonant DCT has been proposed for residential applications. Resonant DCT operating modes have been analyzed in all scenarios. In order to make the converter work at its best efficiency, a method of frequency shift and phase shift control is used. Matlab / Simulink is used to verify the control of the output voltage in this way. The limitation and problem of the phase shift control in this topology has also been identified and discussed in the paper by experiment.

Keywords: AC/DC hybrid microgrid, CLLC resonant, Three port DC Transformer, Limitation.
Event-Triggered Model Predictive Control for A Three-Phase Inverter with Output LC Filter

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This paper proposes an event-triggered model predictive control (ET-MPC) method for the three-phase inverter with output LC filter. The proposed method is developed by combining the conventional finite-control-set MPC (FCS-MPC) method and the ET control strategy. The ET control strategy incorporates a preset triggering condition based on the requirement of the regulation performance for the three-phase inverter. When the state of the three-phase inverter activates the triggering condition, FCS-MPC is triggered with the updated state so that the optimal control actions can be generated when it is necessary. If the state of the inverter is within the preset triggering condition, FCS-MPC is suspended and the control actions are held as constant. Consequently, the unnecessary online prediction, online optimization, and the corresponding control actions can be avoided. Therefore, with the tolerance regulation performance, the proposed ET-MPC method can reduce the computational burden of the conventional FCS-MPC. The various simulation studies of the three-phase inverter are conducted and discussed to demonstrate the effectiveness of the proposed ET-MPC method.

Keywords: Event-triggered control, Model predictive control, Computational burden, Inverter.

A Model Predictive Control for Event-Triggered Three-Phase Vienna Rectifiers

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A model predictive control based on event-trigger (ET-MPC) is presented for three-phase Vienna rectifier in this paper. The event-triggered condition of the ETMPC for three-phase Vienna rectifier is derived, which means the MPC scheme is triggered only when the system state exceeds the condition; otherwise, the MPC scheme is suspended and the control signal is held as the last moment. Compared to the conventional MPC with finite control set (FCS-MPC), the satisfactory regulation performance of the Vienna rectifier is achieved by the ETMPC method with less computation burden and switching actions. From the comparison with the conventional MPC method, the effectiveness and correctness of the proposed ETMPC method is demonstrated by the results of simulation experiments.

Keywords: Event-trigger, Model predictive control, Vienna rectifier, Finite control set.
ICIEA 2020 — Abstracts

Session [SS04] S804: Invited Session on Advanced Control Methodologies for Uncertain Dynamical Systems with Industrial Applications (I)

P1125
Adaptive Control of a Voltage-Controlled Magnetic Levitation System with K-filter
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This paper deals with the complex position tracking control problem of magnetic levitation system with parameter uncertainty and external disturbance. This system has openloop instability and non-linearity in electromechanical system. The system dynamics is controlled by a third-order nonlinear differential equation, which consists of the position error subsystem, the mechanical error subsystem and the electrical error subsystem. The position and current state variables can be measured in real time while the velocity state variables cannot be measured. First, the unmeasurable velocity state variable is observed through K-filter. Second, state variables cannot be measured. First, the unmeasurable variables can be measured in real time, while the velocity state variables cannot be measured. First, the unmeasurable velocity state variable is observed through K-filter. Second, combined with adaptive control technology, backstepping method is adopted to design the overall controller of the system. Third, by using Lyapunov function, the stability of the whole nonlinear control system is proved. Then the stability of the system is analyzed strictly. The simulation experimental results show that the designed controller has good tracking performance for the complex reference trajectory.

Keywords: Magnetic Levitation System (MLS), K-filter, Backstepping, Adaptive control, Lyapunov function.

P1135
Fault Detection, Isolation and Estimation for Linear Systems with Partial Disturbance Decoupling
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Fault detection, isolation and estimation problems for linear systems with partial disturbance decoupling are studied in this article. By using singular value decomposition technique and geometric approach, the detailed design and implementation of partial disturbance decoupling are presented. On this basis, observers are designed, whose most important character is that each observer is affected by only one particular fault. By using Laplace transform, fault isolation strategy is addressed. A simulation example is presented to show the validity and effectiveness of the proposed approach.

Keywords: Fault detection and isolation, Partial disturbance decoupling.

Adaptive Fuzzy Finite-time Control for Switched Nonlinear Inverted Pendulum Systems
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This paper addresses the adaptive fuzzy finitetime control problem for switched nonlinear inverted pendulum systems. The considered inverted pendulum systems are switched model between different springs with under actuated and strongly coupled characteristics. A finite-time controller is constructed by using adding one power integrator technique, adaptive fuzzy control method and backstepping scheme. The proposed control approach is capable of ensuring the semi-global practical finite-time stability for the specific mechanical systems.

Keywords: Switched inverted pendulum systems, Adaptive fuzzy control, Finite-time control, Adding one power integrator technique.

Self-Triggered Control for Nonlinear Systems: A New Design Scenario From the Control Signal Perspective
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In this paper, we consider the self-triggered control (STC) problem for a class of nonlinear systems. Different from the existing results, we provide a new simple yet effective scenario to design the event-triggered control (ETC) and STC conditions from the control signal perspective, i.e. only based on the change of the control signals. In this way, the measurement errors caused by the ETC and STC conditions can be seen as a matched disturbance, thus it can be effectively compensated by carefully designing the controller. With this mechanism, the commonly used input-to-state stability (ISS) assumption with respect to the measurement errors is successfully removed. Two different strategies, i.e. the fixed threshold strategy and the relative threshold strategy, are discussed, and the system stability is proved through Lyapunov analysis.

Keywords: Self-triggered control, Event-triggered
control, Input-to-state stability, Nonlinear systems.

**P1240**

Terminal Sliding Mode Control for Spatial Descent of a Stratospheric Airship

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Addressing the problem of spatial descending control with wind disturbance, this paper presents a spatial path following controller of the stratospheric airship based on the theories of three-dimensional vector field guidance and terminal sliding mode control. Firstly, the nonlinear under-actuated stratospheric airship model is presented. Secondly, the three-dimensional vector field guidance law is designed to calculate real-time desired attitudes of the stratospheric airship for the purpose of guiding the stratospheric airship to follow the desired path. Thirdly, the terminal sliding mode controller is designed to control the airship to follow the desired attitudes. Finally, simulation results validate the effectiveness of the proposed controller.

**Keywords:** Stratospheric airship, Spatial descent, Vector field guidance, Terminal sliding mode control.

**Session [SS05]**

S805: Invited Session on Advanced Control Methodologies for Uncertain Dynamical Systems with Industrial Applications (II)

**P1289**

Event-triggered Adaptive Output Consensus Tracking Control of Uncertain Nonlinear Multi-agent Systems

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This paper investigates the distributed adaptive output consensus tracking problem for uncertain nonlinear multi-agent systems with event-triggered control inputs and event-triggered communication. A new event-based adaptive output consensus tracking scheme is proposed under directed graph condition. To compensate the effects of uncertain external disturbances and event-triggered measurement errors on the dose-loop system stability, an additional parameter estimator is introduced in each agent to estimate the unknown lumped parameter consisting of the upper bound of external disturbances and the triggering threshold. Besides, both continuous monitoring of neighbors’ states and the information of global parameters are not needed in designing the triggering mechanism. It is shown that all the signals in the dose-loop system are globally uniformly bounded and the desired output consensus tracking can be achieved.

**Keywords:** Distributed adaptive control, Uncertain nonlinear multi-agent systems, Event-triggered control.

**P1552**

Adaptive Leaderless Consensus for a Class of Uncertain Nonlinear Systems with Intermittent Actuator Faults

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This paper investigates the leaderless consensus problem for high-order nonlinear systems with unmatched unknown parameters and intermittent actuator faults. Under directed topology condition, a novel adaptive fault tolerant leaderless consensus control scheme is proposed. In order to achieve the leaderless consensus under directed topology condition, an auxiliary system, which is related to the individual states and neighboring states, is introduced in each agent. On the other hand, to compensate the effect of intermittent actuator faults on the system stability of each agent, a local parameter estimator is introduced.

**Keywords:** Distributed adaptive control, Uncertain nonlinear multi-agent systems, Event-triggered control.
to estimate a lumped unknown parameter related to the lower bound of the effectiveness of actuator. It is shown that with the proposed adaptive fault tolerant leaderless consensus control scheme, all the closed-loop signals are globally uniformly bounded and all the agents' outputs can reach a consensus.

Keywords: Leaderless consensus, Adaptive control and intermittent actuator faults.

Event-Triggered Adaptive Control for a Class of Nonlinear Systems with Unknown Time-Varying Parameters

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In this paper, we investigate the event-triggered output tracking problem for a class of nonlinear systems with unknown time-varying parameters. To reduce the communication burden, an event-triggered adaptive control method is proposed by introducing hyperbolic tangent functions in the controller to compensate for the effects of the time-varying parameters. New estimation laws are developed to estimate the bounds of time-varying parameters, where no any prior information about the bounds of unknown time-varying parameters is required. An additional term is introduced in the parameter estimation law to compensate for the effects of unknown time-varying parameters. The proposed control scheme can effectively reduce the communication burden while maintain global stability of the closed-loop system, which means that all the signals are bounded. And the tracking error converges towards an adjustable set, which can be exactly expressed with the user-defined parameters. Simulation results are given to show the performance of the proposed method.

Keywords: Adaptive control, Event-triggered control, Time-varying parameters.

Distributed Adaptive Cooperative Control for a Class of Nonlinear Multi-Agent Systems with Input Saturation

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In this paper, the consensus control for a class of nonlinear multi-agent systems with input saturation is considered. A smooth function is used to approximate the saturation function for every agent, then by combining the adaptive backstepping method and Nussbaum function, a new distributed adaptive cooperative control method is proposed for the multiagent system with input saturation. The consensus tracking errors of the multi-agent system are bounded, and the closed-loop system is globally stable. Simulation results of three-agents with input saturation show the effectiveness and performance of the proposed method.

Keywords: Distributed adaptive cooperative control, Nonlinear multi-agent systems, Input saturation.

Robustness Improvement of Deadbeat Model Predictive Control for Five-phase PMSM Drives

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Deadbeat (DB) model predictive control (MPC) is one of the most advanced control technologies, which has the advantages of fast dynamic response, simple implementation, and low computational-burden. However, DB-MPC still suffers from the problem of parameters mismatch sensitivity, which may deteriorate the performance under the parameters mismatch or uncertainties. This paper proposes a recursive least squares (RLS)-based estimation strategy to improve the robustness of the DB MPC for five-phase permanent magnet synchronous machine (PMSM) drives. With the aid of RLS estimation, the whole PMSM’s parameters can be precisely estimated, hence it can be applied on interior PMSM, as well as surface PMSM. The proposed control algorithm is compared with the conventional DB MPC, and the latest robust MPC algorithm, which is based on the online current difference update mechanism. The simulation and hardware-in-the-loop (HIL) experimental results verify the effectiveness of proposed algorithm.

Keywords: Deadbeat Model Predictive Control (DB MPC), Five-phase Permanent Magnet Synchronous Machine (PMSM), Recursive Least Squares (RLS) estimation.
Improved Imaginary Axis Current Estimation for Single-phase Voltage Source Converters

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This paper presents an improved imaginary axis current estimation (IACE) method based on reference input for dq current control of single-phase voltage source converters (VSCs). A model is established that describes the incomplete dq decoupling of currents. According to this model, the influence of the dynamic performance of IACE methods on the current loop is analyzed. The results show that the dynamic response of the adopted IACE method slows down the current loop. To improve the dynamic performance of the dq current controller in singlephase VSCs, an improved IACE method was proposed and verified by the hardware-in-the-loop (HIL) experiment. The proposed method commits a linear transform with a simple calculation, which provides good steady-state performance and can effectively improve the dynamic performance of the current-loop.

Keywords: Single-Phase Voltage Source Converters (VSCs), dq current decoupling control, Imaginary axis current estimation (IACE), Dynamic performance

Model Predict Torque Control of Induction Motor Based on the DTC Switching Table

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Compared to direct torque control (DTC), model predict torque control (MPTC) is more effective and accurate in VV (VV) selection. This paper presents a novel two-vector MPTC approach based switching table for induction motor drives. The proposed method contributes to significantly reduce torque ripples and stator current harmonics in conventional MPTC by using two VVs in one sampling cycle. The active VVs is determined based on switching table of DTC and cost function. The validity of the proposed method is verified through simulations.

Keywords: MPTC, Switching table, Two-vector, Induction motor.

A Method of the Locomotive Speed Estimation Based on Fuzzy Logic and Extended Kalman Filter

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In this paper, a method is proposed to estimate the locomotive speed based on extended Kalman filter and fuzzy logic, with considering four-axle locomotive model. The wheel speed information is the only known input of the whole estimation system. Firstly, according to the locomotive dynamic model, combined with the extended Kalman filter, the estimated wheel speed and the estimated locomotive speed of each wheel pair can be obtained. Secondly, the estimated creep value and wheel acceleration of each wheel pair are determined by the estimated wheel speed and the estimated locomotive speed. Then the condition of rail surface is judged by the estimated creep value difference between different wheel pairs, and the estimated locomotive speed is further modified to obtain the corrected locomotive speed. Finally, the wheel acceleration and the creep value of each wheel pair are taken as the inputs of fuzzy logic to estimate the final locomotive speed. Simulation results show that this method can accurately estimate the locomotive speed.

Keywords: Locomotive speed, Extended Kalman filter, Fuzzy logic, Four-axle locomotive model.

Direct Instantaneous Torque Control of Switched Reluctance Motor Using Adaptive Excitation Angle

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A novel control strategy is proposed to improve the performance of switched reluctance motor (SRM) in this paper. This control scheme is a combination of proposed strategies including direct instantaneous torque control (DITC) and excitation angle control. Due to the proposed torque control strategy, the torque ripple problem of SRM is transformed into the problem of excitation angle control and the error control between instantaneous torque and reference torque. The current waveform of excitation phase of SRM is automatically improved by using optimized excitation angle. In this paper, the effectiveness of the proposed strategy is evaluated by performing simu-
Non-live Sessions

P1254

Study on Direct Thrust Control of Six-Phase PMSLM Based on Independent H-Bridge Inverters
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On the basis of analyzing the circuit structure and working principle of six-phase permanent magnet synchronous linear motor (PMSLM) based on independent H-bridge inverters, the principle of direct thrust control (DTC) is introduced. In consideration of the independent structure of each phase winding, the spatial distribution of space voltage vectors is illustrated. Following the idea of space vector modulation (SVM), a direct thrust control strategy based on independent space phase voltage vector modulation (SVMDTC) is studied. In each sector, the expected space voltage vector is synthesized by using independent phase voltage vectors on windings of two adjacent phases. Compared with traditional DTC, the simulation results show that the SVM-DTC using independent phase voltage vectors can effectively improve the thrust ripple and stator flux ripple, enhance the ability of anti-interference and achieve better dynamic characteristics.

Keywords: Direct thrust control, Space vector modulation, Independent H-bridge Inverters, Multi-phase PMSLM.

P1608

Pre-Synchronization Control of Grid-Connected Three-Phase Inverters Based On the Characteristics of Synchronous Generators
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A pre-synchronization control strategy for grid-connected three-phase inverters is proposed in this paper, to solve the problem of slow response of the conventional synchronous unit containing a phase-locked loop (PLL), based on the synchronization principle between the synchronous generator (SG) terminal voltage and the grid voltage when there is no power exchanged. In this paper, the voltage control loop and the frequency control loop is analyzed in detail. The influence of the phase tracking principle and parameters of the controller on transient responses of the system is fully discussed. The simulation and experimental results show that the improved three-phase inverter can track the grid voltage rapidly, accurately, and steadily, by using this control scheme without the PLL.

Keywords: Pre-synchronization, Synchronous generator, Virtual impedance, Voltage tracking.

Session [SS07]

Session [SS07] Invited Session on Power Electronics Application

P1224

Modeling and Simulation of Straddle-type Monorail Vehicle Adhesion Control
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As a new type of urban rail transit, the straddle-type monorail is widely used with the key characteristics at the aspects of low cost, fast construction cycle and small impact on urban ecological environment. The poor road conditions may cause adhesion coefficient decrease, then lead to traction force reduce, even cause wheel slip, during the driving process of the vehicle. To analysis and improve the adhesion performance of straddle-type monorail vehicle accurately, a co-simulation model for adhesion control of straddle-type monorail vehicles is built. The model of adhesion control system and traction motor are established by Matlab/Simulink. Then the straddle-type monorail vehicle model is established by multi-body dynamics software Simpack, which analyzing the mechanical structure and dynamic characteristics of straddle-type monorail bogies. The validity of the co-simulation model is verified by the StarSim real-time simulator. Finally, the combined correction adhesion control and adhesion characteristic curve-based adhesion control on the straddle-type monorail are analyzed by the co-simulation model.

Keywords: Straddle-type monorail, Adhesion control, Cosimulation model, Real-time simulator.

P1231

Synthesis and Analysis of Power Management Units for IoT Applications
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As a new type of urban rail transit, the straddle-type monorail is widely used with the key characteristics at the aspects of low cost, fast construction cycle and small impact on urban ecological environment. The poor road conditions may cause adhesion coefficient decrease, then lead to traction force reduce, even cause wheel slip, during the driving process of the vehicle. To analysis and improve the adhesion performance of straddle-type monorail vehicle accurately, a co-simulation model for adhesion control of straddle-type monorail vehicles is built. The model of adhesion control system and traction motor are established by Matlab/Simulink. Then the straddle-type monorail vehicle model is established by multi-body dynamics software Simpack, which analyzing the mechanical structure and dynamic characteristics of straddle-type monorail bogies. The validity of the co-simulation model is verified by the StarSim real-time simulator. Finally, the combined correction adhesion control and adhesion characteristic curve-based adhesion control on the straddle-type monorail are analyzed by the co-simulation model.

Keywords: Straddle-type monorail, Adhesion control, Cosimulation model, Real-time simulator.
This paper describes a systematic procedure using power flow graphs for generating all possible Power Management Units (PMUs) for the Internet of Things (IoT) applications. To maximize the generality of applications, a series of topologies with battery (two ports) and without battery (two ports) are proposed in detail. The operating modes of different topologies are analyzed and summarized in this paper, which provide the meaningful reference of PMUs for IoT applications. Finally, experimental results are presented to verify the analytical results.

Keywords: Power management units, Power distribution, Power flow graph, Internet of things.

P1250
Open-Circuit Fault Diagnosis in Shunt Active Power Filters with No Additional Sensors
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A real-time fault diagnosis method for neutral-point-clamped (NPC) active power filters (APF) is proposed. According to the different relationships between the APF’s harmonic current and reference voltage under normal condition and fault condition, the fault diagnosis algorithm can detect and locate the open-circuit faults (OCF) with no additional hardware or sensors. The selection basis of the two thresholds required by the fault diagnosis algorithm is also analyzed in the article. Fault detection can be achieved in just a few sample periods (in favorable conditions). All the signals used in this algorithm have already been employed in the APF’s controller and only addition and comparison are required in the algorithm, which is very simple. The efficiency of the proposed algorithm is verified by the simulation results.

Keywords: Fault diagnosis, Open-circuit fault, Active power filters, Neutral-point-clamped.

P1258
A DC-link Oscillation Suppression Strategy in Metro Traction Drive System Based on Virtual Damping Resistor
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The negative input impedance with the constant power load causes dc-link voltage and current oscillations in the metro traction drive system (MTDS) and weakens the stability of the system. In this digest, a small signal model of the simplified equivalent circuit of the MTDS is established, and the oscillation mechanism is analyzed. This digest proposes an active damping method based on the virtual damping and pseudolinar enhanced phase-locked loop (PL-EPLL). The stabilization scheme is realized by three parts: 1) the estimation of the dc-link voltage variation; 2) the generation of damping power; and 3) generation of stator current command. The dc-link voltage variation is firstly estimated by the PL-EPLL. And damping power is achieved by virtual damping resistor in series with line inductor. Based on the inverter power control, q-axis current is obtained. Simulation results show that the active damping method effectivly suppresses dc-link oscillation and improves the stability of MTDS. Keywords: Active damping stabilization scheme, Negative impedance, PL-EPLL, Virtual damping resistor, Metro Traction Drive System (MTDS).

P1303
Formal description and verification of vehicle-to-ground communication protocol for guided transport control system
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GTS (Guided Transport System) is a new medium traffic system with low construction cost, short cycle, energy-saving, and high efficiency. It has broad application prospects. In the GTS, the traditional train control system is adopted, and the equipment price is high and does not meet the actual operation scene requirements. To this end, according to the actual demand of GTS, this paper proposes an guided transport control system (GTCS) based on communication and studies the technology of vehicle-to-ground communication, which is the key technology of GTCS based on communication. In order to verify the security of the vehicle-ground security communication protocol, a formal model of the vehicle-to-ground security communication protocol based on communication GTCS is established. Furthermore, it is proved that the communication protocol can guarantee the reliability of the information transmission of the GTCS.

Keywords: GTS (Guided Transport System), Security communication protocol, CPN (Colored Petri Net), Formal Method

P1455
IGBT Open-Circuit Fault Diagnosis of Single-Phase Cascade NPC Rectifiers Based on Residual Rate
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The negative input impedance with the constant power load causes dc-link voltage and current oscillations in the metro traction drive system (MTDS) and weakens the stability of the system. In this digest, a small signal model of the simplified equivalent circuit of the MTDS is established, and the oscillation mechanism is analyzed. This digest proposes an active damping method based on the virtual damping and pseudolinar enhanced phase-locked loop (PL-EPLL). The stabilization scheme is realized by three parts: 1) the estimation of the dc-link voltage variation; 2) the generation of damping power; and 3) generation of stator current command. The dc-link voltage variation is firstly estimated by the PL-EPLL. And damping power is achieved by virtual damping resistor in series with line inductor. Based on the inverter power control, q-axis current is obtained. Simulation results show that the active damping method effectivly suppresses dc-link oscillation and improves the stability of MTDS. Keywords: Active damping stabilization scheme, Negative impedance, PL-EPLL, Virtual damping resistor, Metro Traction Drive System (MTDS).
In order to realize the real-time open-circuit faults diagnosis of insulated gate bipolar transistors (IGBTs) of singlephase cascaded neutral point clamped rectifiers (SPCNPCR), an open-IGBT fault diagnosis method based on residual rate is proposed. First, a hybrid logic dynamic model (MLD) of a singlephase cascaded midpoint clamped rectifiers is established to estimate the input voltage and grid current. Then, compared with measured voltage and current, the changes of voltage residuals are obtained to locate the fault cells, and change rates of current residuals are obtained to analyze residual characteristics of IGBT faults through the theoretical analysis and simulation, respectively. The specific switch signal combination test is used to achieve the detection and location of single IGBT open-circuit faults in different modules. The simulation results have illustrated the proposed diagnostic method has good diagnostic performance.

Keywords: Single-Phase Cascaded Neutral Point Clamped Rectifiers (SPCNPCR), IGBT open-circuit fault, Mixed Logic Dynamic (MLD) model, Residual changing rate.

Session [SS08] S080: Special Session on Smart manufacturing System and Data Analytics

P1065

Machine OEE Monitoring and Analysis for a Complex Manufacturing Environment
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OEE (overall equipment effectiveness) is a well-established KPI metric to measure the equipment effectiveness. OEE has been widely used for many industry as a quantitative tool for measuring productivity. The biggest challenge in the OEE implementation is due to the complexity of the plant with many variety of machines. In this paper, we present a unified OEE data collection method that is able to connect both brown field legacy machines and green field machines. An integrated OEE monitoring system architecture is proposed for large scale of implementation. A case study demonstrates the successful implementation of the OEE system for the productivity improvement.

Keywords: OEE, OPC UA MQTT, Machine utilization data acquisition, Brown field, Green field. productivity Improvement.

P1369

MVmed: Fast Multi-Object Tracking in the Compressed Domain
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We present MVmed, an algorithm for real-time online tracking of people and objects in MPEG-4 and H.264 compressed videos and integrate it into a multi-purpose tracking software for manufacturing sites. To support arbitrary video sources with no prior setup our tracker needs to be compatible with a variety of video codecs and camera settings. Existing compressed domain trackers are limited in this regard. They require a fixed interval of key frames, use only P frames and usually support only a single codec. MVmed overcomes these limitations and supports both MPEG-4 and H.264 codecs, P and B frames and arbitrary key frame intervals. On the MOT17 benchmark MVmed achieves a MOT A of 45.3% at 42.1 Hz (266.9 Hz without detection) which is as accurate but significantly faster than the previous state of the art in compressed domain tracking. With this work we release the source code of MVmed and a Python package for motion vector extraction from videos.

Keywords: Multi-Object tracking, Compressed domain, Motion vectors.

P1506

Smart Pegging and Release Control for Multi-product Production Testbed with Shopfloor Visibility
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This research focuses on the development of coupled order-tray pegging and release control strategy for a multiproduct production system. Pegging is a process of assigning work-in-progress parts to customer orders. Release control is to determine when, which and how raw materials should be released into the manufacturing system. Based on actual production scenarios of our manufacturing testbed, we build a simulation model incorporating real-time visibility of production status, and implement the algorithm such that orders are fulfilled efficiently and new production is pulled by the demand. It is demonstrated that the proposed strategy outperforms the as-is strategy in terms of the average cycle time of orders, since in as-is, trays of parts are assigned according to their registration sequence, and releases are scheduled based on plan. Moreover, the results feedback to the production system could support follow-up dispatch decisions.

Keywords: Pegging, Release control, Real-time visibility, Manufacturing execution.
Unsupervised Probability Matching for Quality Estimation with Partial Information in a Multiple-Instances, Single-Output Scenario

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A new learning problem is presented in this study based on an injection moulding dataset from the semiconductor industry. Multiple instances share a single output, i.e., a many-to-one relationship and supervised learning methods cannot be directly applied. To address this problem an algorithm is proposed which performs unsupervised probability matching between each instance and an output, generating a training dataset with a one-to-one relationship. This data is then passed to a supervised learning method (k-nearest neighbours with dynamic time warping) for inference. Comparisons are made with a number of traditional machine learning techniques where the inputs are naively flattened. Preliminary results show that the proposed algorithm achieves a better classification of defects across most of the evaluation metrics.

Keywords: k-nearest neighbours, Dynamic time warping, Mean shift clustering, Injection moulding

FM-based Supervised Learning for Categorical Data Classification in Manufacturing Process

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For complex manufacturing process, the raw features are always in a heterogeneous manner that contains lots of high dimensional process parameters and categorical targets (e.g., product quality “Pass” or “Fail”) without numerical measurements. It makes the classification problems quite challenging. To improve the classification accuracy, additional data structure is necessarily considered, e.g. feature interactions. Factorization Machines (FM) is a general classification method which considers the effect of feature interactions. Preliminary results show that FM-based methods improve the classification accuracy about 2.49%-5.94% compared with conventional classification methods.

Keywords: Manufacturing process, Factorization machines, Feature interactions, Supervised learning

Incorporation of Ship Motion Prediction into Active Heave Compensation for Offshore Crane Operation

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Ship motion has significant effects on certain maritime applications like offshore crane operation. In particular, the vertical heave motion is undesired for safe transferring, accurate positioning and subsea installation. In recent years, there have been growing tasks in utilizing ship motion data for online operation improvement based on the development of virtual simulation environment, digital twin and automatic remote-control systems. How to effectively utilize ship motion data is fundamental to these tasks. This paper presents a neural-network-based method to predict ship motion and use the prediction to improve active heave compensation (AHC) of offshore crane operation. A virtual prototype of the lifting system is developed including implementation of the proposed AHC algorithms. A multilayer perception model is trained to predict ship motion. By feeding the future motion of the ship into the controller, the lifting performance can be tested in the virtual environment and the result can be applied to its counterpart. Through simulation with measured sensor data, the proposed method is verified efficient in improving crane operation performance.

Keywords: Hybrid simulation, Neural network, Active heave compensation

Semi-automatic Approach to Create Fish Image Datasets for Aquaculture Applications

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Continuous monitoring of wild fish populations and their interaction with farmed fish is important, not only for marine biologists, but also for the aquaculture sector. Nowadays many efforts are made in trying to recognize fish species underwater effectively. Different techniques of computer vision and deep learning are being proposed to solve this problem, but only few benchmarks of fish species are available. To address this problem, we propose a semi-automatic approach to create fish image datasets for aquaculture applications in Norway. The proposed approach uses a neural network to automatically detect fish in live images and compare with the simulated images for the same species. The results show that the proposed approach is effective in creating datasets for fish species recognition.

Keywords: Fish species recognition, Image processing, Machine learning
Development of Onboard Decision Supporting System for Ship Docking Operations
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Maritime operations are inevitably influenced by the wind, wave, sea currents, and other perturbations at sea. Providing decision support for these operations based on historical and real-time data of ship status is thus of great concern in terms of ship safety. However, it is challenging for collecting and analysing large quantities of ship data in real operations. Moreover, the development of an onboard decision support system (DSS) will be a gradual and iterative process subject to extensive testing and simulation. Consequently, the paper presents an integrated simulation framework which provides testing and simulation environment for the DSS development. The system enables navigation data transmission from a well-designed simulator and automatic determining of the safe maneuver of a ship within the framework. The development of DSS is divided into three steps. The ship maneuvering data from simulator is collected; the data is then classified and fed into an imitation learning (IL) algorithm to learn an initial policy; the result is further applied to a reinforcement learning (RL) algorithm for safe decision making of the operation. In this paper, the paper presents an integrated simulation framework with experience replay for safe decision making of the operation. The simulation results demonstrate that the proposed DSS could assist the shipmaster in deciding policies and improve the efficiency of decision making.

Keywords: Ship docking, Decision support system, Imitation Learning (IL), Reinforcement Learning (RL).

P1399
Modeling of Offshore Crane and Marine Craft in Wave Motion
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Safe handling of heavy payloads in an offshore environment requires careful planning and depends on the interaction between a crane and a vessel. This paper investigates the coupled dynamics between a multipurpose crane with payload, and an offshore carrying vessel. A classical multibody model is derived using holonomic constraints and Newton-Euler kinetics. The resulting index-3 system of differential-algebraic equation (DAE) is transformed into an index-1 system and solved using commonly used numerical ode solvers. Numerical simulations are carried out to show that the proposed models behave in a physically realistic manner.

Keywords: Mathematical modeling, Offshore cranes, Multibody dynamics, Newton-Euler method, Marine craft.

P1480
A Human-Expertise Based Statistical Method for Analysis of Log Data from a Commuter Ferry
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The proposed method in this paper aims to better understand the log data from the commuter ferry. By the method, the mechanism of how the human expertise operates the ferry can be found, and this help to establish ship intelligence for the autonomous commuting sailing. The log data of sailings with the same departure and arrival ports is of interest in this respect. The method defines different phases of a sailing as different scenarios in terms of the features contained in the collected data. The features are reflected by the ship behavior/response and the ship machinery/actuators. Compared to the typical sailing phases which are distinct to each other, the features can be uncertain when the ferry transfers from the current phase to the sequential. The concept of the transition time window is thus raised to interpret the uncertainty between adjacent phases. Based on the collected data, the human expertise is involved to summarize features and generate empirical
criteria for the decomposition. After the whole sailing being split into a sequential-scenario series, statistical heat maps are drawn to illustrate the likelihood site with respect to the collected log data. In practice, log data collected from a customized commuting route in Trondheim are analyzed by the proposed method.

Keywords: Data analysis, Commuter ferry, Autonomous surface vehicles, Decision support.

P1551

Broad Learning System-Based Adaptive Optimal Course-Keeping Control of Marine Surface Vessel

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In this paper, a novel optimal control method by broad learning system (BLS)-based adaptive dynamic programming is proposed. This method is used to coursekeeping control of ship under the conditions of unknown system dynamics, energy saving and reduced equipment waste. First, it is necessary to identify the unknown nonlinear dynamics in the ship’s course keeping system, so a model network is established by BLS: Then, a BLS based optimal control scheme is proposed, the data used for the BLSs training is composed of current data and recorded data. The connection weights of the approximator is obtained by real system without need of iteration. Therefore, compared with the traditional adaptive dynamic programming (ADP) algorithm that requires multiple iterations, BLS-based ADP prove the effectiveness and high performance of the proposed optimal control law for course-keeping in ship autonomous driving.

Keywords: Course-keeping, BLS, ADP, Optimal control.
propose a framework combining the MPC with a learning-based error estimator and a feedforward compensator to improve the path tracking accuracy. An extreme learning machine is implemented to estimate the model based predictive error from vehicle state feedback information. Offline training data is collected from a vehicle controlled by a model-defective regular MPC for path tracking in several working conditions, respectively. The data include vehicle state and the spatial error between the current actual position and the corresponding predictive position. According to the estimated predictive error, we then design a PID-based feedforward compensator. Simulation results via CarSim show the improvement accuracy of the predictive error and the effectiveness of the proposed framework for path tracking of an autonomous vehicle.

**Keywords:** Path tracking, Model predictive control, Machine learning, Feedforward compensator, Autonomous vehicle.

P1557

Path Planning Method Design and Dynamic Model Simplification of Free-Flying Space Robot
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Space robot is indispensable for complex operations such as in-orbit maintenance of spacecraft, space debris defense, etc. In this paper, a path planning method based on joint parameters is proposed to resolve the problem of dynamic singularity while planning the trajectory for free-flying space robot. Parameters-interpolating is used in this path planning method to convert the equation of path planning motion based on generalized Jacobian matrix to nonlinear equations with the solution of numerical calculation. In this way, the path planning process of free-flying space robot merely takes forward kinematics problem into consideration. Therefore, the dynamic singularity problem is resolved. Meanwhile, a nonlinear analytical method of dynamic model is also proposed in this paper to access to the engineering application of space robot. This method is used to reduce the computational complexity of in-orbit operation process while keep the accuracy of the planning result. Methods proposed in this paper have broad prospect of applications for space robot.

**Keywords:** Free-Flying space robot, Dynamic model simplification, Path planning, Dynamic singularity.

P1564

Control Strategy of Lunar Lander-Relay Satellite Antenna Acquisition and Tracking for Chang'e-4 Lunar Exploration Mission
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This paper presents a framework combining the MPC with a learning-based error estimator and a feedforward compensator to improve the path tracking accuracy. An extreme learning machine is implemented to estimate the model based predictive error from vehicle state feedback information. Offline training data is collected from a vehicle controlled by a model-defective regular MPC for path tracking in several working conditions, respectively. The data include vehicle state and the spatial error between the current actual position and the corresponding predictive position. According to the estimated predictive error, we then design a PID-based feedforward compensator. Simulation results via CarSim show the improvement accuracy of the predictive error and the effectiveness of the proposed framework for path tracking of an autonomous vehicle.

**Keywords:** Path tracking, Model predictive control, Machine learning, Feedforward compensator, Autonomous vehicle.

In this paper, based on detailed analysis of the interruption items and uncertainties of HGA pointing, a control strategy of lunar lander-relay satellite HGA acquisition and tracking is proposed for reliable relay communication for Chang’e-4 lunar mission. According to different conditions, strategies of “fast scanning in large-scale” and “slow scanning in small-scale” are designed. Also criteria and basic requirements on the ground for implementation are depicted. Finally, verification results are demonstrated. The control strategy mentioned in this paper is widely used for narrow-beam HGA pointing of lunar exploration mission and is of bright prospect on application for space exploration missions in the coming future.

**Keywords:** Chang’e-4 lunar exploration mission, Relay communication between the Moon and Earth, HGA, Control strategy for antenna acquisition and tracking.

P1580

Multi-Layer Scheduling Optimization for Intelligent Mobility of Maritime Operation
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In this study, multi-layer scheduling optimization algorithms are proposed and validated based on historical vessel operation data in maritime terminals. The most relevant KPIs are average wait time, average turnaround time and berth occupancy rate presented in this study. Through the proposed optimization algorithms, the results shown that average wait time and turnaround time are significantly reduced with increasing of randomness threshold, which is a threshold to allow reschedules to buffer terminals. The average wait time and turnaround time are shortened by around 27.30 hrs (by 39.06%) and 39.41 hrs (by 27.30%)}
Robust Energy Management for Uncertain Microgrid Using Modified Grey Wolf Optimizer

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Uncertainties of renewable energy sources (RES) power generation and load demand have detrimental effects on the microgrid operation. In this paper, a robust optimization approach based on modified grey wolf optimizer is proposed to determine the optimal energy management for a typical microgrid with regard to uncertainties. Furthermore, the influence of uncertainty budget for RES power generation and load demand on operation cost and pollutant gas emissions are studied. Simulation results show a good reduction both in operation cost and pollution emissions, as well verify the effectiveness of our proposed approach.

Keywords: Robust optimization, Energy management, Uncertainty, Modified grey wolf optimizer, Microgrid.
Non-live Sessions

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P1386
Comprehensive Characterization Method of Fault-tolerant Kinematics Ability for Space Manipulator with Joint Locked Failure
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After the joint locked failure occurs of space manipulator, in order to complete the subsequent operation tasks, the fault-tolerant kinematics ability of the manipulator needs to be accurately characterized. In this paper, aiming at the space manipulator with joint locked failure, the kinematics modeling of the space manipulator is used to analyze the singularity indexes which can perform the fault-tolerant kinematics ability from the joint space level and operation space level. Then, the comprehensive characterization of fault-tolerant kinematics ability for manipulator with joint locked failure is realized by utilizing the entropy method.

Keywords: Space manipulator, Joint locked failure, Fault-tolerant kinematics ability.

P1411
Design of an Underactuated Body Fixture for a 7-DOF Cable-Driven Upper Limb Exoskeleton
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Rehabilitation robots can provide effectively motion training for neural impaired patients. When developing rehabilitation exoskeletons, the design of physical connections between the device and the human limb to which it is connected is a crucial problem. A seven-degrees-of-freedom cable-driven upper limb exoskeleton is designed for physical therapy, which preserves the advantages with both cable-driven device and parallel mechanism. In this paper, in order to reduce the kinematic uncertainties caused by instabilities when wearing the exoskeleton, a novel under-actuated body fixture which can adapt to the contours of human upper limb is designed. Simulations and experimental results are included to show the effectiveness of the research.

Keywords: Cable-driven device, Exoskeletons, Fixations, Rehabilitation robotics, Wearable robot.

P1450
Variable Structure Compensation PID Control for Lower Extremity Exoskeleton
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In this paper, a portable lower extremity exoskeleton is designed to assist the operator in weight-bearing walk. The whole exoskeleton has an anthropopathic structure, and each leg has six joint DOFs. The structure is the simplification of human joints in consideration of weight loss, the valve-controlled asymmetrical hydraulic cylinder is used as actuator in knee joint to bear load while walking. The variable-structure compensation PID control method, (VSCPID), is proposed to implement the position tracking of knee joint. This method combines traditional PID control and sliding-mode control by adding the variable structure part associated with sliding surface to the PID control, so the controller can achieve robustness without the requirement of accurate system model. Meanwhile, the global stability of this approach can be proved through Lyapunov methods in the presence of bounded disturbances. The contrast experiments between the proposed control and PID control illustrate that VSCPID control can improve the tracking performance and has good robustness. In addition, the sigmoid function is employed in VSCPID to solve the chattering problems encountered in the experiments.

Keywords: Exoskeleton, Hydraulic system, Nonlinear control, Lyapunov method.
In this paper, we focus on the topic of adaptive control of the trajectory of the lower limb exoskeleton, and our ultimate goal is to establish a design principle of a controller in order to achieve natural human-like locomotion. We suggest dynamical movement primitives as a central pattern generator (CPG) of lower limb exoskeleton, this approach combines nonlinear oscillators (i.e. dynamical system that exhibit limit cycle behavior), this system can spontaneously generates trajectories for the robot. And by introducing adaptive factor, our control system is mathematically capable of learning the high level features (frequency, envelope, etc.) of a periodic input signal. Besides, we introduced foot pressure feedback into the system, and designed related hardware. Numerical simulations and experimental implementation on a physical robot demonstrate the effectiveness of the proposed locomotion controller.

Keywords: CPG, Adaptive oscillator, Synchronization, Trajectory generation, Limit cycle, Phase reset.

Session [SS12] SS12 Invited Session on Computer Vision and Pattern Recognition

P1454
An Initial Study to Use Deep Reinforcement Algorithm to Improve Efficiency of Emergency Response

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Emergency decision making problem is an significant problem in emergency response area. Existing solutions for emergency decision making usually seek for the most similar historical emergency response events with current one, then apply the corresponding response process, which lacks of real-time capability. With the development of machine learning, reinforcement learning stands out for its strong learning ability and wild application in decision making. This paper proposed an approach that translates emergency decision making problem into reinforcement learning problem, and developed an agent can generate optimized strategy for emergency decision making using deep reinforcement learning method.

Keywords: Emergency decision making, Strategy, Deep reinforcement learning, Machine learning.

P1461
Autocorrelation Convolution Networks Based on Deep Learning for Automatic Modulation Classification

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Automatic modulation classification (AMC) is challenging but significant in the field of cognitive radio. Despite recent deep learning methods have dominated as the best performance for AMC, they are challenged by the practical problem in low signal-to-noise ratios (SNRs). In this paper, we propose novel autocorrelation convolution networks (ACNs) to capture periodic representation for communication signals. In ACNs, modulation modes are classified with the periodic local features under an autocorrelation convolution criterion. The experimental results demonstrate that ACNs achieve a great improvement that outperforms recent deep learning methods in low SNRs.

Keywords: Deep learning, Modulation classification, Cognitive radio, Wireless communication.

P1462
Deep Convolutional Neural Network with Wavelet Decomposition for Automatic Modulation Classification

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In cognitive radio, signal recognition is an important technology and modulation recognition plays a key role in it. With the development of artificial intelligence, deep learning algorithms applied in automatic modulation recognition have developed quickly, whereas they usually depend on a large number of labeled samples for training. Few samples directly affect the network convergence, which will lead to network overfitting and cannot achieve good results. The loss of prior information makes feature extraction more difficult. In this paper, we propose a wavelet-decomposition-based algorithm for modulation recognition to solve the small sample size problem. To obtain rich information relatively, we adopt the wavelet function to analyze signals from multiple scales, extract the time
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P1507

3D Semantic Segmentation Algorithm for Indoor Scenes based on Long-term Memory
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Deep learning has a strong ability to tackle pixel-level labeling tasks in image understanding. However, the disorder and irregularity of 3D point cloud data make it difficult to be applied. Though there are a few approaches that have acquired satisfied results on 3D data processing recently, there is no consideration of the relationships between each point, which plays an important role in indoor objects semantic segmentation and has been proved on plane images. In this paper, a spatial long-term connection of points is modeled by a fully connected conditional random field (CRF) to enhance the memory ability of the network. Since it is infeasible to compute due to the dimension explosion caused by potentially fully connected CRF, a highly efficient method in utilizing linear combination of multiple Gaussian kernels is proposed to approximate it. Finally, the CRF has been integrated into the deep learning framework, making it trainable end-to-end. The test evaluation of the experiments show that this network reaches current benchmarks and have a strong performance on public 3D indoor datasets. From these results, it is concluded that the relationships of each pair of points are conducive to semantic segmentation for indoor scenes.

Keywords: 3D semantic segmentation, Deep learning, Conditional random field, Long-term memory.

P1519

An Adaptive Gradient Method with Differentiation Element in Deep Neural Networks
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Current adaptive gradient algorithm (such as Adam) used in deep neural network has the advantages of fast training speed, simple tuning task and high computational efficiency. However, these methods are usually based on the gradient update using the root mean square of the past gradient, which often causes the learning rate shock. Thus the model overshoot may be large and even cannot converge. The PID optimization algorithm for deep neural network provides a new way to solve this problem. It introduces the idea of automatic control to solve the problem of overshooting in the stochastic gradient algorithm. The Adam algorithm is similar to an adaptive PI controller. Inspired by this, the differentiation element is introduced into Adam algorithm to accelerate model convergence. The algorithm was tested on MNIST, Cifar-10, Cifar-100 and Tiny-ImageNet data sets in the section of experiment. It is shown that the training speed by 10% on the premise of guaranteeing the accuracy of the model.

Keywords: Adaptive optimizer, Gradient descent, Differentiation element.

P1514

Design of Embedded Target Tracking System Based on MobileNet and KCF
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With the development of computer technology, people pay more attention to target detection and tracking technology. The computer vision technology can be used to detect and track the target in the monitoring scene. However, the tracking algorithms are usually programmed on the computer platform and cannot be utilized for automatically tracking, which severely limits the application scope of the target tracking system. In this paper, we construct a target detection and tracking system based on the embedded development board and image analysis technology. The inbuilt MobileNetSSD network model is utilized and the improved kernel correlation filtering (KCF) target tracking algorithm is transplanted to the embedded development board. The video data is collected through the external camera and the tracking information is output to the display screen in a real time. At last, an experimental platform is built to verify the feasibility of the tracking algorithm based on the embedded development board.

Keywords: KCF, MobileNet, target tracking, target detection, embedded system.
This paper addresses dim target detection of multiband infrared data. First, the dynamic model of the target in the multi-spectral infrared image sequence and the measurement model of the multi-spectral infrared image sequence are established. Then, the particle filtering algorithm for single target tracking before detection is studied. Based on this, combined with sequential measurement fusion strategy, the algorithm is proposed for detection and tracking of dim moving targets from multi-spectral infrared image sequences. Finally, the validity of the proposed algorithm is verified by simulation experiments combined with the posterior probability and root mean square error of the target.

Keywords: Dim target, Track-before-detect, Multi-spectral, Particle filtering.

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**Session [SS13] — SS13: Special Poster Session (I)**

**P1550**

**Dim Target Track-Before-Detect based on Particle Filtering**

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This paper addresses dim target detection of multiband infrared data. First, the dynamic model of the target in the multi-spectral infrared image sequence and the measurement model of the multi-spectral infrared image sequence are established. Then, the particle filtering algorithm for single target tracking before detection is studied. Based on this, combined with sequential measurement fusion strategy, the algorithm is proposed for detection and tracking of dim moving targets from multi-spectral infrared image sequences. Finally, the validity of the proposed algorithm is verified by simulation experiments combined with the posterior probability and root mean square error of the target.

Keywords: Dim target, Track-before-detect, Multi-spectral, Particle filtering.

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**P1345**

**Edge Enhancement in Monocular Depth Prediction**

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Although many monocular depth prediction methods have achieved very high prediction accuracy, the preference of using high-level features of images makes these methods wrongly predict the depth of edge regions. This shortage does not decrease prediction accuracy seriously but will bring difficulties to subsequent works like three-dimension recognition and semantic segmentation. To enhance the performance of restoring the depth of edge regions, we apply modification on network structure and design a new loss function to strengthen the network’s ability to extract, store, and utilize low-level features of images. We test our method on NYU Depth V2 Dataset, and the experiment results show that our method has a better performance on predicting the depth of edge regions than the state-of-the-art method and outperforms most of the current method on prediction accuracy.

Keywords: Monocular depth prediction, Deep learning, Edge enhancement.
Mechanical Design and Optimization on Lower Extremity Rehabilitation Robot

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For patients with lower limb dysfunction, the center of gravity will move vertically and horizontally when performing rehabilitation training on a bench-type rehabilitation robot. At present, most of the exoskeleton robots use the fixed suspension method for patients, and the matching between the exoskeleton and the patients in the process of movement is poor. This paper designs an exoskeleton robot with an adaptive weight reduction system. The exoskeleton uses the tension sensor to detect the auxiliary force in real time and is used in the closed-loop control of the weight reduction system. The exoskeleton’s backrest can move laterally from left to right, which can effectively adapt to the change of the center of gravity during the patient’s movement. Firstly, the paper introduces the whole structure design of exoskeleton, including legs, back plate, damping system, bench and treadmill. Secondly, the forward and inverse kinematics of the exoskeleton legs are analyzed, and the exoskeleton’s workspace and Jacobian matrix are solved. Finally, the main parts of exoskeleton are analyzed by workbench to check the strength and stiffness requirements.

Keywords: Rehabilitation robot, Finite element analysis, Mechanical design, Kinematic analysis.

Virtual Test Modeling Method of Environment Control System in Aircraft

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With the continuous development of aircraft environmental control system technology, the system architecture and its working environment are becoming more and more complex, and the importance of ground environment simulation test is increasingly prominent. In the world, no matter in the military or civil field, simulation analysis and virtual test have become an essential link in the process of system establishment and implementation, and have produced significant benefits. The establishment of an excellent virtual test system plays an important role in improving the theoretical analysis means, system construction, troubleshooting, control system research and construction, and also improves the working efficiency of the whole test task. In the integration verification of aircraft environmental control system and ground environmental simulation system, the complex thermal cycle system is involved, and the operation parameters of each equipment seriously affect each other. It is impossible to accurately understand the actual operation of the system only by using the traditional fixed state point theory. Therefore, it is necessary to use the advanced method based on differential equation to carry out dynamic simulation of environmental simulation test research.

Keywords: Aircraft environmental control system, Virtual test, Modeling method, Simulation.
Research on PCIe Bus Communication Based on NeoKylin
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This paper will discuss the research on PCIe bus communication based on NeoKylin. This paper discusses the design of the board that supports the PCIe bus communication and the development of the relevant software based on NeoKylin in detail. This paper presents the realization of PCIe bus communication based on NeoKylin. In addition, this paper gives the design scheme of the hardware circuit and the mentality of developing the relevant software. This paper can be thought as the theoretic bases and the guidance of the research on PCIe bus communication in some degree. Keywords: NeoKylin, PCIe, Hardware board.

Research on Reconfigurable Technology and a Design of Application
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Along with the development of microelectronic technology, reconfigurable technology based on FPGA devices has shown wide application prospect, especially when it comes to solving the practical application problems of miniaturization, integration and generalization of aircraft test equipments. It is regarded as the key part for designs to meet the complete functional requirements in different application scenarios, while reducing weight and power consumption. As progresses of the application verification of FPGA and SOC devices, a better solution could be figured out by the aid of reconfigurable technology. With comprehensive research of general reconfigurable technology carried out, a design of microcomputer modules group based on general reconfigurable technology is proposed in this paper. Along with the unique advantage of FPGA being brought...
Simulation Technique of Optical Properties and its Applications for Complicated Appearance of Aeronautical Transparencies
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The analysis platform is of paramount importance in design of aeronautical transparencies. This study proposes an engineering estimation and optimization method for transparencies appearance and the corresponding optical performance after the exploration of theoretical calculation of optical properties and image simulation for aeronautical transparencies, and a precise and efficient analysis platform was provided to design aeronautical transparencies. During design process of transparencies, one can find out and eliminate the optical defect in time after evaluating the optical properties accurately by utilizing the simulation results. After multiple optimization, a trade-off among aerodynamic, stealth and optical performances can be obtained, and the risk for future research and production can be reduced significantly.

Keywords: Optical angular deviation, Optical distortion, Simulation.

Learning-based Remote Photoplethysmography for Physiological Signal Feedback Control in Fitness Training
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Remote photoplethysmography (rPPG) has attracted much attention in recent years. This research proposes to apply rPPG to the fitness training scenario, enabling non-contact measurement of the subject's heart rate during training. Currently, most existing approaches suffer from a major weakness, i.e. the subject’s body needs to remain stably while conducting measurement, which significantly hinders practical applications of the approach. The main purpose of this paper is to build a training system based on rPPG and fitness machines to provide users with better ergonomic exercise experiences. We have built a spinning bike system that combines a camera and an adaptive controller based on heart rate feedback for tracking the desired exercise intensity. Fuzzy control is introduced in the feedback control loop by considering heart rate and heart rate variability simultaneously for better representation of the physical status. Some preliminary results are briefly presented. This research demonstrates promising performance improvement by combining rPPG heart rate estimation and fitness machine control.

Keywords: Remote Photoplethysmography (rPPG), Adaptive control, Fitness training, Image signal processing.
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Session [SS15]  SS15: Special Poster Session (III)

P1627
Dynamic Analysis and Controller Design for the Ballbot
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A ballbot is a dynamically stable mobile robot that shows the capability of omnidirectionality, agility, and maneuverability on a floor. This paper presents the design prototype and control scheme of a ballbot. By assuming that the effect of noise is a Gaussian noise, a Kalman estimator is applied to estimate the internal state of the system. To improve the trajectory tracking performance of the ballbot, a Linear Quadratic Tracking (LQT) controller is designed to balance and transfer the ballbot system taking into account the presence of noise in the system, and the numerical simulation results imply the correctness of the system modeling and effectiveness of LQT control design for a MIMO ballbot system.

Keywords: Ballbot, Lagrangian method, LQT control, Kalman filter.

P1347
Anthropomorphic Flexible Joint Design and Simulation
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In this paper, a two-degree-of-freedom (DOF) anthropomorphic pneumatic flexible joint is designed by using a silicone based hyperelastic material. The flexible joint consists of three chambers, which are distributed at 120 degrees, and they are not connected with each other. The pneumatic flexible joint is controlled by inflating high pressure gas to its chambers. Bending properties and motion space of the pneumatic flexible joint are analysed. And the influence of the chambers’ sizes and intervals on the joint’s curvature and motion space is analyzed through a series of finite element models (FEMs). Finally, the design of the geometrical sizes of the pneumatic flexible joint is studied qualitatively. Finite element analysis (FEA), under gas pressure of 10 kPa, 15 kPa, 20 kPa and 25 kPa, respectively, shows that the designed structure could realize two-degree-of-freedom motion of the pneumatic flexible joint, which makes up for the deficiency of traditional one-degree-of-freedom pneumatic flexible joints.

Keywords: Flexible joint, Soft actuator, Pneumatic actuator, Anthropomorphic joint.

P1355
Vehicle Trajectory Recognition based on Video Object Detection
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Highway always has high-speed traffic flow, which means that frequent lane changes will easily cause large risk. So, lane changes are often not allowed on complex sections, such as tunnel, long downhill section, etc. Vehicle trajectory recognition from the video can help the administration monitor and analyze the movement of the vehicles. In this paper, we choose a one stage object detection network called Yolo to detect vehicles from the surveillance video camera. Data augmentation, focal loss, and synchronized batch normalization are applied to improve the performance of detector. After successful vehicles detection, a vehicle box matching method based on IOU is applied to identify whether a detected vehicle is a recorded vehicle or new one. The results show that the object detection and tracking method can detect and track vehicle is stable, the trajectory recognition achieves high reliability.

Keywords: Object detection, Surveillance video, Vehicle trajectory, Yolo.

P1366
Motion Characteristic and Analysis of Bionic Jellyfish with Fluid-Driven Soft Actuator
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This paper presents a kind of bionic jellyfish robot with fluid-driven soft actuator. The jellyfish robot is based on the motion research of natural jellyfish. The motion characteristics of fluid-driven soft actuator are studied, and the motion performance of the soft actuator are simulated by using finite element analysis method. The improved kinematic and dynamic model of jellyfish is established...
considering the non-linear function of the projected area of the robot jellyfish. Combined the fitting projected area function and the dynamic model, a threefactor study is conducted to determine the impact that the length, thickness, and width have upon the velocity of the bionic jellyfish. It is found that all three of these factors significantly impacted velocity. According to the result of the simulation, the new structure and design requirement: velocity meet 13mm/s and swing frequency range from 0.25Hz to 0.5Hz.

Keywords: Bionic jellyfish, Soft actuator, Dynamic model, Simulation.

P1376
Control for Networked Control Systems with Multiple Controllers
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The finite horizon optimal LQG control problem for networked control systems with a remote controller, a local controller and communication channels with packet dropouts and transmission delays is investigated in this paper. The contributions of this paper are as follows: We derive a non-homogeneous relationship between the state and the output of systems in the case of transmission delays, and we can meet the design requirement: velocity meet 13mm/s and swing frequency range from 0.25Hz to 0.5Hz.

Keywords: Optimal control, Remote and local controllers, Packet dropout, Delay, Maximum principle.

P1377
Research on Modeling and Planning Method of Distribution Network with New Energy and Special Load
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A large number of special loads brought with economic development and the extensive access of new energy will have a series of impacts on the power grid. The opinion that the special load and new energy generation system may offset each other’s impact on the power grid is put forward in this paper. Based on that, the distribution network planning method with a variety of special loads and new energy generation system is studied. In this paper, two kinds of new energy power generation systems, (wind power generation system and photovoltaic power generation system) and two kinds of special load, (electric vehicle charging station and electric arc furnace) are taken as the research objects. They are modeled respectively and different combinations are considered. Finally an example is given to verify the method in the paper.

Keywords: New energy generation system, Special load, Distribution network optimization planning.

At present, the design of the test process during the manufacturing process of the aircraft is mainly performed by the personnel to consult the relevant data of the tested object to obtain the test information, and manually write the test process file. Therefore, the writing efficiency is low and the writing quality relies heavily on the experience of craftsmen, and the standardization and standardization of process files cannot be effectively guaranteed. On the other hand, the test program is closely coupled with specific test equipment. The upgrade and update of test resources cause the test program to change, which increases the use and maintenance costs. This paper proposes to implement standardized modeling of test knowledge based on the Automatic Test Markup Language (IEEE 1671 A TML), to support the sharing, transplantation and reuse of the test information, and to standardize and digitize test process files. At the same time, the automatic generation of signal-oriented test cases is achieved, the interchangeability of test instruments and the portability of test programs are solved, and the universal execution of various test resources is achieved.

Keywords: Automatic Test Markup Language IEEE-1671 standard, Universal test system, Cloud platform, Test cases, Signal-oriented.

P1378
Cloud-based Test Modeling and Automatic Generation of Test Cases
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At present, the design of the test process during the manufacturing process of the aircraft is mainly performed by the personnel to consult the relevant data of the tested object to obtain the test information, and manually write the test process file. Therefore, the writing efficiency is low and the writing quality relies heavily on the experience of craftsmen, and the standardization and standardization of process files cannot be effectively guaranteed. On the other hand, the test program is closely coupled with specific test equipment. The upgrade and update of test resources cause the test program to change, which increases the use and maintenance costs. This paper proposes to implement standardized modeling of test knowledge based on the Automatic Test Markup Language (IEEE 1671 A TML), to support the sharing, transplantation and reuse of the test information, and to standardize and digitize test process files. At the same time, the automatic generation of signal-oriented test cases is achieved, the interchangeability of test instruments and the portability of test programs are solved, and the universal execution of various test resources is achieved.

Keywords: Automatic Test Markup Language IEEE-1671 standard, Universal test system, Cloud platform, Test cases, Signal-oriented.

P1412
Research on High Precision Positioning Servo Control of PMSM
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For the high-precision position control of the two-dimensional turntable, the mechanism of the positioning error of the two-dimensional turntable is analyzed first, the key factors affecting the tracking accuracy are proposed, and the index decomposition method of the two-dimensional turntable is proposed to guide the design of the two-dimensional turntable drive system. By establishing a closed-loop control model of a two-dimensional turntable; an improved control algorithm based on classic PID control is proposed. Through experimental verification on the product, the steady-state accuracy of the two-dimensional turntable reached 1 µrad.

Keywords: Tracking error mechanism, Positioning index decomposition, Improved PID control algorithm, Experimental verification.

Session [SS16] SS16: Special Poster Session (IV)

P1424
Research on the Performance Evaluation of Lithium-ion Battery Cascade Utilization Based on Impedance Spectrum
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In order to evaluate the performance of lithium-ion battery in cascade utilization, a fractional order equivalent circuit model of lithium-ion battery was constructed based on electrochemical impedance spectrum, and the parameters of the model were identified by complex nonlinear least square regression. Using fractional calculus as a tool, the SOP estimation of lithium-ion battery based on impedance spectrum model is realized. A BP neural network is constructed and trained by impedance spectrum data of different aging stages in cycle aging experiment. The SOH estimation of lithium-ion battery is needed for the BTMS. However, the existing thermal models of lithium ion battery cannot give consideration to both the efficiency and accuracy of calculation. In this paper, a reduced-order thermal model (ROTM) was established to estimate the temperature distribution of lithium ion batteries online. Firstly, the ROTM can be obtained by projecting the eigenfunctions to the thermal equation of the lithium-ion battery using Galerkin method. Finally, the accuracy and efficiency of the ROTM was verified by comparing with the finite element method (FEM). The computational results of the ROTM are in very good agreement with that of FEM, but the ROTM can save more computational time. Thus, such ROTM can be applied to the real-time processing control of BTMS.

Keywords: Impedance spectroscopy, SOH estimation, SOP estimation, Fractional order model.

P1425
Active Fault-Tolerant Control for Multi-agent System in Dynamic Tracking
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When carrying out dynamic tracking mission, especially criminal tracking or security patrol, the multi-agent system will face problems such as terrain constraint, communication fading and single-agent failure, which leads to avalanche-type effect to the whole system. An active fault-tolerant control method is proposed to guarantee task execution capability of the multi-agent system, which is a combination of a consistent time-varying formation tracking control and differential evolution-based self-reconstruction for control instructions. And a simulation platform of the multi-agent system is built to test and verify the proposed theory. The results show that the multi-agent system with this active fault-tolerant control strategy can track a dynamic target even facing communication failure.

Keywords: Multi-agent, Dynamic tracking, Active fault-tolerant, Differential evolution.

P1428
A Reduction Method for Thermal Modeling of Lithium-ion Battery based on Proper Orthogonal Decomposition
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Battery thermal management system (BTMS) is crucial to ensure the safety and performance of lithium ion battery. To reflect the temperature distribution of the battery, an accurate thermal model of lithium ion battery is needed for the BTMS. However, the existing thermal models of lithium ion battery cannot give consideration to both the efficiency and accuracy of calculation. In this paper, a reduced-order thermal model (ROTM) was established to estimate the temperature distribution of lithium ion batteries online. Firstly, the proper orthogonal decomposition (POD) method was used to extract eigenfunctions from the thermal field of lithium-ion battery. Secondly, the ROTM can be obtained by projecting the eigenfunctions to the thermal equation of the lithium-ion battery using Galerkin method. Finally, the accuracy and efficiency of the ROTM was verified by comparing with the finite element method (FEM). The computational results of the ROTM are in very good agreement with that of FEM, but the ROTM can save more computational time. Thus, such ROTM can be applied to the real-time processing control of BTMS.

Keywords: Lithium-ion battery, Galerkin projection, Proper orthogonal decomposition, Reduced order thermal model.
An Electrochemical Thermal Coupling Model for High C-rate Discharge and Internal Heating for Lithium-ion Batteries

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There are many situations in which lithium-ion batteries are required to discharge at high C-rates in engineering applications. However, the battery model cannot be well simulated in the high C-rate. In this paper, the electrochemical thermal coupling model parameters are modified in order to solve the problem of insufficient simulation accuracy at high C-rate discharge. The modified model takes into account the effects of non-uniform concentration distribution and ion current density changes on the model parameters during reaction polarization, solid-phase diffusion, and liquid-phase diffusion, and the relevant parameters are fitted with the current.

Keywords: Lithium-ion batteries, Electrochemical thermal coupling model, High C-rate discharge, Constant current discharge.

Research on Low Temperature Internal AC Heating Device for Lithium-Ion Battery

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At low temperatures, lithium-ion batteries have problems such as difficulty in discharging and decaying of discharge capacity. Internal heating methods have become the first choice to improve the low-temperature performance of lithium-ion batteries. But the AC current is typically generated by an onboard equipment with external power supply, which is a main bottleneck of the ac heating applied to electric vehicles. To address this difficult issue, an automotive internal AC heater is proposed to heat lithium-ion batteries at low temperatures without the requirement of external power supplies. The heating device by means of interleaved buck-boost topology enables lithium ion battery “self-heating”, and the heating speed can be online regulated by controlling the switching frequency. In this paper, the model analysis and simulation of the heating topology, and Set up a low-temperature heating experimental platform for lithium-ion batteries demonstrate the feasibility and effectiveness of the program. Experimental results show that the proposed heater can heat 18650 cylindrical LiFePO4 batteries rapidly.

Keywords: Lithium-ion battery, Internal heating, Buck-boost topology, Low temperature.

Experiment Design: Intelligent Traffic Management System

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In order to solve the problem of road congestion, a smart traffic management system is designed in this paper. The hardware control language Verilog for FPGA is used to implement logic control. The RS232 serial port and UART communication protocol are used to realize data communication and status visualization. YOLOv3 is used in conjunction with OpenCV for data collection. Combined with the shortest path optimization algorithm, an intelligent transportation scheme is given. Analog circuits are built using Proteus software for simulation verification. And the laboratory experiment box is used for physical verification.

Keywords: Traffic light, FPGA, Verilog, RS232, YOLOv3, Analog circuits.
RUL Prediction of Lithium Batteries based on DLUKF Algorithm

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Lithium batteries have been widely used in various fields, but there are still some safety problems. Once an explosion occurs, people’s lives and property will be damaged seriously. In order to strengthen the safety of lithium batteries, it is necessary to master the maintenance of lithium batteries technology. Accurate prediction of the remaining useful life (RUL) of lithium batteries is beneficial to the maintenance of the battery, so that its safety can be improved. The traditional unscented Kalman filtering (UKF) method has been used in RUL prediction of lithium batteries, but there are still some problems such as low prediction accuracy because of the system's high non-linearity. In this paper, an improved unscented Kalman filtering method for predicting the RUL of lithium batteries is used. The formula for calculating the weights by particle filter (PF) is used to change the weights in the UKF, and then in order to get the state and covariance at the next moment, the changed weights are additionally used in the measurement mechanism. The new method is verified more accurately by the open source battery capacity decay data from Center for Advanced Life Cycle Engineering.

Keywords: Lithium batteries, RUL, UKF, PF.

Mining Diagnostic Knowledge from Spacecraft Data Based on Spark Cluster

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Compared with the data obtained from ground simulation experiments, the spacecraft telemetry data can better reflect the real working state of the spacecraft. How to effectively utilize telemetry data and extract effective information is an important issue. This paper uses diagnostic data from real spacecraft telemetry to mine diagnostic knowledge and build a diagnostic knowledge base. Compared with the traditional fault diagnosis method based on expert knowledge, the diagnostic knowledge mined can enrich the existing expert knowledge base. In this paper, the FP-Growth algorithm is used to mine the association rules of the parameters to obtain the diagnostic knowledge, and a satellite telemetry data diagnosis knowledge base is constructed. Mined diagnostic knowledge includes association rules among parameters, and the relationship between parameters and faults. In addition, due to the large number of telemetry parameters, the amount of data reaching TB level, the Spark distributed computing cluster is used to implement distributed and efficient computing of the algorithm. Finally, building a spacecraft telemetry data mining diagnostic platform with the Django architecture.

Keywords: Telemetry data, Big data mining, Association rules, Spark cluster, Distributed computing.

A Hierarchical Testability Analysis Method for Reusable Liquid Rocket Engines Based on Multi-Signal Flow Model

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Considering the characteristics of reusable liquid rocket engines, a hierarchical modeling method of Reusable liquid rocket engines testability based on multi-signal flow model is proposed. Then, a testability model at whole engine, subsystem and component level is constructed. Testability analysis, calculation of testability indices and design improvement are conducted to verify the feasibility of the proposed modeling method. This study may provide a feasible way to future design of reusable liquid rocket engines testability.

Keywords: Hierarchical model, Testability analysis, Fault detection, Fault isolation.

6LoWPAN Protocol Based Infrared Sensor Network Human Target Locating System

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This paper proposes an infrared sensor human target locating system for the Internet of Things. In this design, the wireless sensor network is designed and developed to detect human targets by using 6LoWPAN protocol and pyroelectric infrared (PIR) sensors. Based on the detection data acquired by multiple sensor nodes, K-means++ clus-
Research on Target 3D Reconstruction and Measurement Technology based on Binocular Vision and Lidar

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At present, the research on target 3D reconstruction and pose measurement is hot issue in the field of computer vision. This paper proposes a method of target 3D reconstruction and pose measurement. It is considered that the 3D image of scene can be recovered by using the visible binocular camera according to the geometric relationship of corresponding points between images. The amount of information is large and the details are rich. However, due to the input data, it brings sensitivity to the change of environmental light. Sense, the weak texture region is difficult to match. Lidar can directly measure the three-dimensional information of the scene by emitting laser, which has the advantages of accurate measurement and little influence by external environment changes, but it has the disadvantages of sparse data and low scanning frequency. Based on the characteristics of binocular camera and lidar, aiming at the 3D reconstruction and pose measurement of the target, this paper studies the 3D reconstruction and pose measurement method of the spatial target based on lidar and visible light, and studies the pose measurement method by identifying the typical features of the target, so as to provide a solution for the 3D reconstruction and measurement of the object.

Keywords: Laser radar, Binocular vision, 3D reconstruction, Pose measurement.

Optimal Dispatching Model of Active Distribution Network Considering Uncertainty of Demand Response

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With the development of active distribution networks, the uncertainty of demand response is an important adjustable resource, which is introduced into the distribution network system to ensure the safe, stable, and economic operation of the distribution network system under the combined action of distributed generation, energy storage, and other equipment. However, the uncertainty of the external environment in the response process and the uncertainty of the price demand curve make the demand response have greater uncertainty in the current active distribution network system. Based on this, considering the reliable and economical operation of active distribution network, a scheduling optimization model of active distribution network considering demand response uncertainty is proposed in this paper, aiming to minimize the operating cost. The model is linearized by piecewise linearization model.

Keywords: Demand response, Uncertainty, Piecewise linearization, Optimization dispatch model.
Disturbance Observer Based Robust Adaptive Control of Maglev System
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In this paper, a robust adaptive controller based on disturbance observer (DO) is proposed to solve the tracking problem of uncertain maglev systems subjected to timevarying mismatched disturbance. Firstly, the nonlinear dynamic of maglev system is transformed into linear system by feedback linearization. The extended disturbance observer is introduced into the robust adaptive control to handle a large class of timevarying mismatched parametric uncertainty and disturbance for the maglev system. The stability of the closed-loop system is proven in the paper. The simulation results verify the effectiveness of the proposed controller at last.

Keywords: Maglev system, Mismatched uncertainty, Robust adaptive control, Disturbance observer.

Stiffness Estimation and Intention Detection for Human-Robot Collaboration
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In this paper, we propose a stiffness estimation and intention detection method for human-robot collaboration. The human arm endpoint stiffness can be obtained according to the muscle activation levels of the upper arm and the human arm configurations. The estimated endpoint stiffness of human arm is matching to the robot arm joint stiffness through an appropriate mapping. The motion intention of human arm is detected based on the wrist configuration which is recognized by a Myo armband attached at the forearm of the operator. In order to reduce the time of feature engineering to ensure the performance of real-time collaboration, the wrist configuration recognition is realised based on the neural learning algorithm. The sEMG of the human forearm is directly fed into the neural network after processing by filters and sliding windows. The force sensor at the end of the robot arm is embedded in the feedback loop to make the robot arm better adapted to the operator’s movement. The results of experiments performed on Baxter robot platform illustrate a good performance and verifies the proposed method.

Online Parameter Estimation For Uncertain Robot Manipulators With Fixed-time Convergence
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For traditional parameter estimation schemes of uncertain robot, most of them were proposed to identify unknown parameter with desired precision, but few of them focused on the convergence time. Recently finite-time estimation techniques have been proposed by scholars to achieve estimation in finite time. In this paper, we proposed a novel estimation scheme for uncertain robot systems with fixed time instead of finite time. In order to avoid using acceleration signals during the estimation, a kind of auxiliary filtering technique was employed. Besides, a continuous and recursive update law was employed for the parameter estimation such that the computational burdens of real-time inversion of square matrices could be avoided. Finally the effectiveness of the identification algorithm is verified based on a 2-DOF uncertain robot model.

Trajectory Tracking Control of Robotic Manipulators by Multi-layer Neural Networks
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Neural networks (NNs) based trajectory tracking control of robotic manipulators has been studied extensively in the literature. However, its use for off-the-shelf commercial robotic systems is limited due to their explicit position- control architecture. In this paper, we aim to address this critical issue by developing an approach to design the reference trajectory of a robotic manipulator by using multi-layer NN or deep NN (DNN). First of all, a desired trajectory is given to a robot and tracked by the robot under its embedded closed-loop control. Then, the actual trajectory and desired trajectory are used as input and output of a DNN model and to train its parameters. This approach does not require access to the robot’s inner control loop or the knowledge edge of the robot’s dynamics, and thus provides feasibility.
A control method based on global fast terminal sliding mode control (GFTSMC) technique is proposed to track desired trajectories of a quadrotor UAV. By taking into account the high-order nonholonomic constraints to control the six degrees of freedom system with four inputs. The whole system control can be divided into position control unit and attitude control unit, adopt GFTSMC to achieve reference position and attitude. And because of the characteristic of GFTSMC, the robustness and timeliness of the convergence process of the quadrotor system can be guaranteed.

**Keywords:** Global fast terminal, Sliding mode, Quadrotor UAV, Robustness, Timeliness.

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**Session [SS19]**

SS19: Invited Session on System Design and Test

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**P1363**

A Novel Intelligence-Based Pan-Tilt Platform System for Measuring the Trajectories of Parachute

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We design a pan-tilt platform system for measuring the trajectories of multiple targets automatically, aiming at obtaining the trajectories of multi-targets in the airdrop test, such as the trajectories of the airplane, the pilot chute and the main chute. We also design a multi-targets switch tracking algorithm, or MTST, which based on YOLO and SiamRPN++ tracking algorithm for this pan-tilt platform system. Unlike the existing Multiple Object Tracking (MOT) that tracks several targets simultaneously, the proposed MTST tracks target one by one. As in an airdrop test, the airplane in the scene will be tracked first, then the tracking target will be switched to pilot chute when it is ejected from the airplane. The main chute will be the tracking target when it is thrown from the pilot chute. A large number of experiments prove that the proposed MTST has high anti-jamming capability and high reliability.

**Keywords:** Airdrop, Multi-targets switch tracking, Intelligence-based pan-tilt platform system, Computer vision.

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**P1371**

Design and Research of an Automatic Charging System for Electric Vehicles

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An automatic charging system is designed to connect the charging pile and the electric vehicle in this paper. The system includes three subsystems: the charging hole positioning subsystem, the automatic charging execution subsystem, the communication / control subsystem. After receiving the charging command, the system can select the nearest idle charging pile, move the charging gun according to the path, find and locate the charging hole of the vehicle, so as to realize automatic charging. After charging, the charging gun can be put back in place according to the path and wait for the next charging command. The system adopts the combination of approximate positioning and precise positioning, and the combination of overall movement and precise control. It can not only make multiple electric vehicles share charging piles, but multiple charging piles share the automatic charging system. In addition, compared with the mobile robot moving in any direction, the cost is greatly reduced.

**Keywords:** Automatic charging system, Approximate/precise positioning, Overall movement/precise control.

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**P1398**

Research on Payload Distribution of UAV Formation with Constraints

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In order to solve the problem of the distribution of limited combat power and payload in the multi-tasking cooperative scenario of the UAV formation, this paper proposes a decision method based on the NSGA-III algorithm. First, the NSGA-III algorithm is combined with the penalty function to solve the multi-objective optimization problem with constraints. Then, build a capability evaluation system for mission formations, and build a multi-objective optimization model with constraints for multi-tasking collaborative scenarios. Finally, the improved NSGA-III algorithm with the penalty function is utilized to solve the constrained multi-objective optimization problem. This method can...
propose a variety of non-inferior deployment schemes for multi-task collaborative scenarios with limited payload resources in a short time, effectively reduce the formulation time of schemes and improve the performance of tasks.

**Keywords**: UAV formation, Multitask collaboration, Multi-objective optimization, NSGA-III.

**P1419**

A New Framework and Implementation Technology of Deep Collaborative Front-End Computing

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In order to further enhance the perception ability of mobile devices and promote their development towards intellectualization and autonomy. On the basis of the existing related research, aiming at the typical problems existing in the current research, the lightweight machine learning framework for collaborative computing is carried out. This framework can implement object detection methods such as Haar and Adaboost, HOG and SVM. It mainly discusses the practicality of manually designed features for mobile platforms. In order to further improve the system performance, the research on efficient computer vision technologies such as object detection and tracking related theories and technologies is carried out with embedded equipment with the artificial intelligence chip as the core processor.

**Keywords**: Collaborative theory, Object detection, Algorithm transplantation.

**P1489**

Anomaly Detection for Spacecraft using Hierarchical Agglomerative Clustering based on Maximal Information Coefficient

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The spacecraft’s telemetry data is the only basis for the ground transportation management system to monitor its on-orbit operating status. Anomaly detection of spacecraft has become an important means to enhance the reliability of spacecraft on-orbit operation. There are many ways to detect anomalies in spacecraft. With the increasing amount of telemetry data and the improvement of modern computing capabilities, anomaly detection methods have gradually transitioned to data-driven methods. Because the data-driven approach does not require a large amount of expert experience, it also tolerates that operators do not have sufficient theoretical knowledge. However, telemetry data has the characteristics of large scale, high dimensions, complex relationships, and strong professionalism. These bring severe challenges to achieve high detection rates, low false detection rates, and strong interpretive goals for anomaly detection methods.

Current spacecraft monitoring systems generally only perform anomaly detection for a single parameter, and few studies have provided clear and effective methods for multivariate anomaly detection. This paper proposes an anomaly detection method for multivariate telemetry data. The idea is to propose a hierarchical clustering method based on the maximum information coefficient, mining the correlation between telemetry parameters, grouping the telemetry parameters to form a subspace; using the LSTM method to perform single-parameter anomaly detection on the subspace; using weighting The averaging method integrates the anomaly detection results in the subspace to achieve multivariate anomaly detection. The experiments were performed on a real satellite historical data set of the Beijing Aerospace Flight Control Center. The expert evaluation of the agency proves that the method proposed in this paper is feasible and can preliminary excavate the correlation between telemetry parameters. Although the accuracy needs to be improved, there is still room for optimization.

**Keywords**: Spacecraft, Anomaly detection, Hierarchical agglomerative clustering, Maximal information coefficient, Multivariate.

**P1124**

Optimal Synchronization Interval in the PS-PWM based MMCs with Sub-module Asynchronism

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Modular Multilevel Converters for HVAC applications normally adopt a distributed control system to manage considerable submodules (SMs) in the system, where a large number of local controllers are employed. The manu-
Polynomial Fitting

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Keywords: Field limiting rings, SiC JBS, Polynomial fitting.

Owing to the demand for larger wind turbine generators, the megawatt wind energy conversion system using the modular multilevel converter (MMC) has shown great potential in this area. However, the capacitor voltage of this topology is floating, which leads to the requirement of large capacitor and the increment of project cost. This paper proposes a minimal capacitor voltage ripple (MCVR) control for the MMC-based wind energy conversion system. In the method, the second and third harmonic components of the capacitor voltage are controlled to counteract its fundamental component. With the proposed MCVR control, the capacitor voltage ripple can be reduced without influencing the maximum power point tracking of the wind energy conversion system. Finally, the effectiveness of the proposed method is validated in MATLAB/Simulink.

Keywords: Modular multilevel converter, Control strategy, Capacitor voltage ripple, Wind energy conversion.
upper layer and operation optimization in the lower layer considering active management. According to the changing trend of China’s power consumption level, the phase of planning is divided into several stage scenarios based on the medium and long-term load data. The proposed co-optimization model in this paper was solved by particle swarm algorithm. The simulation results of the 33-bus distribution network discussed the benefits of the operational scenarios with correlation between uncertain factors in the distribution network planning. The effectiveness of the proposed multi-stage scenarios model was demonstrated by using the numerical results.

Keywords: Electric power system planning, Distributed power generation, Correlation method, Multi-stage planning, Uncertainty analysis, Mathematical models.

For each follower, which can avoid conflicts among agents when the formation transforms. The effectiveness of this policy is verified by a simulation experiment.

Keywords: Multi-agent, Formation transforming policy, Planetary exploration.

In this paper, a novel model of a switched reluctance generator is established. And based on the idea of object-oriented modeling, the stator, rotor, power converter, current chopper, and PID controller of the switched reluctance generator are modeled. And Modelica is used as the modeling language. The most complex part of building a switched reluctance generator model is its nonlinear characteristics. There are two nonlinear relations. The first one is that the machine flux linkage is dependent on the stator current and rotor position. Another one is that the electromagnetic torque is also dependent on the stator current and rotor position. The nonlinear characteristics are generally described by the finite element method and the function approximation method. This paper uses both methods to establish a switched reluctance generator model, and then compares the simulation results of the models established by the two methods. The model of the switched reluctance generator established in this paper is a three-phase self-excited switched reluctance generator with three pairs of stators and two pairs of rotors as an example.

Keywords: Switched reluctance generator, Modelica, Modeling and simulation, Object-oriented modeling.

For the future planetary explorations, this paper studies the formation transforming policy for multi-agent system in uneven terrain. Based on the leader-follower strategy, a formation transforming policy considering terrain factors is proposed. This policy sets different elliptical trajectories for each follower, which can avoid conflicts among agents when the formation transforms. The effectiveness of this policy is verified by a simulation experiment.

Keywords: Multi-agent, Formation transforming policy, Planetary exploration.
time, because Bitcoin does not have a unified regulatory agency, the Bitcoin blockchain has also brought a series of problems, such as drug transactions and online money laundering. Therefore, node information in the Bitcoin blockchain network needs to be collected and analyzed. Problematic transactions should be analyzed and the source should be traced accurately. This article mainly explains the basic technical principles and data structure of the Bitcoin blockchain, and summarizes the latest research on the data analysis of the Bitcoin blockchain network nodes in recent years. At the same time, relevant data for the last 100,000 blocks in the Bitcoin blockchain are collected and the recent changes in the data of the Bitcoin blockchain network nodes are showed in preparation for further analysis. Finally, the analysis of node data of the Bitcoin blockchain network is summarized and prospect.

Keywords: Blockchain, Bitcoin, Data analysis.

**P1522**

Write Amplification Trade-off Analysis in Hybrid Mapping Solid State Drives

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Write amplification defines the efficiency of write operation, and it directly affects the Input/Output operations per second (IOPS) and endurance of NAND flash memories. The logupdated write scheme of NAND flash based Solid State Drives will renewal data in different places. Garbage collection will cause extra I/O operations which affects the write amplification factor. Hybrid mapping scheme alleviates the large size of mapping table in page mapping scheme, and the IOPS of storage devices in block mapping scheme, so the write amplification factor. Hybrid mapping scheme allows the write amplification factor and maintain the endurance at a high level.

Keywords: Write amplification, NAND flash memory, Hybrid mapping, Garbage collection.

**P1572**

Analysis of Shaft Voltage in Rotor Permanent Magnet Synchronous Motor System for Traction

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Rotor permanent magnet motor is the most common permanent magnet motor. Permanent magnet motor is widely used in traction system because of its high efficiency, high power factor and small volume. The shaft voltage is one of the main reasons for bearing failure. Common mode voltage is one of the most important reasons for the generation of shaft voltage. In this paper, the influence of common mode voltage on the shaft voltage of IPM and SPM motors is studied, the shaft voltage analysis model is established, and the influence of coupling capacitance on the shaft voltage is discussed. The results provide reference for the design of motor and the suppression of shaft voltage.

Keywords: Permanent magnet synchronous motor, Shaft voltage, Common mode voltage.

**P1566**

Improved Model Predictive Flux-linkage Control of Permanent Magnet Synchronous Motor Based on Fast Vector Selection

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The conventional model predictive control (MPC) of permanent magnet synchronous motor (PMSM) always has a complicated computational burden and large current or torque ripples, which result in deteriorated control performance and difficult to achieve practical operating conditions. To address those issues, this digest proposes an improved model predictive flux-linkage control (MPFC) strategy for PMSM without weight coefficients. The proposed scheme retains excellent control performance of MPC with simple calculation. Firstly, according to the mathematical model of PMSM, the prediction model of flux-linkage is established. The relationship between flux linkage and selected voltage vector is analyzed and a new sector division solution is discussed. Then, the design and implementation of the improved MPFC scheme is presented. Finally, a comprehensive simulation test has been conducted to verify the effectiveness of the proposed scheme.

Keywords: PMSM, Weight coefficient, Fast vector selection, Flux-linkage control.

**P1576**

Cooling System Design and Thermal analysis of a PMSM for Rail Transit

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Cooling system design and thermal analysis of a PMSM for rail transit system. The main reasons for bearing failure. Common mode voltage is one of the most important reasons for the generation of shaft voltage. In this paper, the influence of common mode voltage on the shaft voltage of IPM and SPM motors is studied, the shaft voltage analysis model is established, and the influence of coupling capacitance on the shaft voltage is discussed. The results provide reference for the design of motor and the suppression of shaft voltage.

Keywords: Permanent magnet synchronous motor, Shaft voltage, Common mode voltage.
In the field of rail transit, permanent magnet synchronous motor (PMSM) is widely used due to high power density, high efficiency and small volume. Temperature is an important factor affecting motor performance, so it is necessary to analyze the temperature of the motor. In this paper, the thermal analysis considering thermal contacts and the cooling system design for a permanent magnet synchronous motor are investigated. The calculation methods of heat source and heat transfer coefficient are introduced. The finite element method (FEM) is used for temperature analysis. In the simulation model, the copper and insulation of the winding are simplified into an equivalent material. Finally, the cooling effects of axial direction and circumferential direction are compared.

Keywords: Cooling system, Thermal analysis, PMSM, Rail transit.

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Design of EtherCAT Slave System Based on Zynq-7020 Chip
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EtherCAT provides clear advantages of fast speed, flexible topology, accurate synchronization and efficient communication. To meet the needs of high-speed and real-time communication of servo motors, a Zynq-7020 chip from Xilinx and an ET1100 chip from Beckhoff are used to establish a new slave system. Hardware, software and design process are analyzed. Through a series of tests on the slave station, it has been proved that the I/O communication between the master and the slave is fast, the synchronization performance is good, and the slave system works stably under the EtherCAT protocol.

Keywords: EtherCAT, Zynq, Slave System, Multi-axis motor control.

The Design of University Staff Data Management System Based on MBSE
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This paper introduces the application of Model-Based Systems Engineering (MBSE) methodology in the normal conceptual design stage of data management system. With the university personnel data management system as an example, it establishes the model diagram on Rhapsody platform through Systems Modeling Language (SysML), and defines the forward design process of the key functional architecture of MBSE. From the system top-level model building to the user fuzzy demand acquisition, finally, taking data audit as an example, the activity diagram and sequence diagram models are built, which provide direct reference for software development. Because of the replacement of text description by models, this methodology realizes the full decoupling of system functions, ensuring a consistent understanding of system description by all stakeholders and accordingly the effective reduction of the system iterative cost.

Keywords: MBSE, System design, Rhapsody.

High-resolution Thermopile Array Sensor-based System for Human Detection and Tracking in Indoor Environment
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This paper proposes an indoor multiple human detection and tracking system based on a high-resolution thermopile array sensor. The sensor is deployed at the height of 3m with a vertical downward view. The infrared data of the detection area collected by the sensor is called thermal distribution. The sensor obtains 24+32 pixels thermal distribution. The thermal distribution data is first preprocessed by interpolation and filtering. Then, the background is removed by an adaptive threshold. The high temperature regions and their center points of human targets are obtained by a weighted meanshift method. The thermal feature of a high temperature region is the sum of temperature in the region. Finally, through the space distance and the thermal feature, the center points of high temperature regions are associated with the corresponding human trajectories. Due to the high resolution of thermopile array sensor, the tracking system has a good accuracy, and it can handle the detection and tracking of multiple humans close to each other as well.

Keywords: Human detection, Tracking, Infrared, Thermopile array sensor.
Large flowrate fuel metering valve is a critical regulating unit in the afterburner of aero-engine. Study on the flowrate metering valve is essential for optimizing the flight envelope of aero-engine. Addressing the problem of the low control accuracy of fuel flowrate, this paper proposes a new double control chamber metering valve to improve the pressure sensitivity and decrease the zero position error of the electrohydraulic servo valve. Meanwhile, by adding the damping piston in the main stage of constant pressure difference compensation valve, the pressure difference variation between inlet and outlet of the metering valve can be suppressed effectively. Firstly, mathematical models of the metering valve are derived. Then, the optimized system can be built on the AMEsim platform to analyze the pressure-flow characteristics. The result indicates the new large flowrate fuel metering valve has better performance than the original one in flowrate stability and control accuracy. The conclusion is of essential guidance for the optimum structural design and intelligent control of the metering valve.

**Keywords:** Large flowrate fuel metering valve, Afterburner, Aero-engine, AMEsim.

### P1396

**Distributed Formation Control of Autonomous Underwater Vehicles Without Velocity Measurement**

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This paper addresses the distributed formation control problem of autonomous underwater vehicles moving in horizontal plane without velocity measurement. A novel output-feedback formation protocol is proposed based on leader-following strategy while assuming that only a subset of followers know the information of leader. First, a distributed observer is designed for each follower to estimate the information of the leader and extended state observers are designed to estimate the unmeasured velocities as well as to recover lumped uncertainties induced by parameter perturbations and external disturbances. Based on the observation results, the formation tracking laws are designed in kinematic and dynamic level, while desired tracking performance and robustness are guaranteed. It is proved that estimation errors and formation tracking errors converge to an arbitrarily small neighborhood of zero. Simulation results are finally presented to validate the effectiveness of proposed strategy.

**Keywords:** Formation control, Autonomous underwater vehicle, Leader-following, Distributed observer, Extended state observer.

### P1420

**A Single-phase Voltage Source Inverter With Lower-Voltage-Rated Capacitor and Ripple Power Decoupling Function**

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This paper proposes a single-phase inverter with active power decoupling and lower-voltage-rated capacitor. The proposed inverter is deduced by moving the position of the capacitor in the exiting circuit. Then, the voltage stress of the capacitor is reduced significantly. In addition, two dual closed-loop control methods are developed to achieve maximum power point tracking (MPPT), dc-link voltage regulation, decoupling capacitor voltage maintenance, and the grid-tied current control. Finally, a 400-W prototype is constructed to verify the abilities of the proposed circuit.

**Keywords:** Active power decoupling, Low-frequency ripple power, Dual closed-loop control, Lower-voltage-rated capacitor.

### P1441

**Input Impedance Modeling of Single-Phase Voltage Source Rectifier With Consideration of Frequency-Coupling Effect**

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Time-periodicity and non-linearity pose a challenge to the precise input impedance modeling of single-phase power converters. In this study, a precise input impedance model with measurability of the single-phase voltage source rectifier (VSR), which considers the frequency-coupling effect (FCE), is established. Meanwhile, it is revealed that the rectifier input impedance is dependent of the grid impedance. In the proposed modeling approach, only Laplace transform and frequencyshifting operation are required, which avoids the complicated convolution calculation in the frequency domain. In addition, the influence of grid impedance on the input impedance is studied. Simulations are conducted to verify the effectiveness of the proposed method.

**Keywords:** Input impedance, Single-phase voltage source rectifier, Frequency-coupling effect.
A Hybrid AC/DC Microgrid Energy Management Strategy Based on Neural Network

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An energy management strategy (EMS) for hybrid AC/DC microgrid is proposed in this paper. Since the accuracy of microgrid management is affected by the error of power prediction, this proposal is aiming to improve the economic performances of a microgrid while considering the prediction error. The management process is divided into 3 stages: day-ahead scheduling, intraday pre-scheduling and intraday scheduling. Economic performance is considered as the most important factor in the day-ahead scheduling stage. In this situation, the power forecast results are used to calculate the management command. Neural network is introduced in the management strategy of intraday pre-scheduling stage. In this process, the model of power generation, energy storage and other devices of microgrid is proposed, which is important for the dispatch of next stage. This process can reduce the error of management caused by power forecast. In the stage of intraday scheduling, the models of microgrid are taken used to calculate the dispatching command. The power forecasting results are used in this stage. Simulation results are shown in this paper and verified the effectiveness of the proposed strategy. The economic performances and operation reliability of the microgrid are both improved.

Keywords: Microgrid, Energy management, Neural network, Economic performance.

A Reactive Component Elimination Method for Voltage and Current Stresses Analyses

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Traditional ways of applying amperes-second and volt-seconds balances have commonly been adopted for calculating state variables of a converter. However, it becomes tedious and error prone when using complicated topologies having many inductors and capacitors. Therefore, to simplify the circuit analysis, a reactive component elimination method has been proposed in this letter to be applied for all converter topologies. To demonstrate the method, current and voltage stresses of a coupled-inductor impedance-source inverter have been determined using both the traditional and the proposed methods. Their subsequent comparison confirms the effectiveness of the proposed method.

Keywords: Converters, Reactive component elimination, Voltage stresses, Current stresses.
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