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

09-13 November 2020
Kristiansand, Norway

PROGRAMME & ABSTRACTS

Organised by:

University of Agder, Norway, IEEE Industrial Electronics Chapter of Singapore, IEEE Singapore Section.

Financial and Technical Co-Sponsor:

IEEE Industrial Electronics Society

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Brief Contents

Message from the General Chairs Info-2

Committees

Organizing Committee Info-4
International Advisory Committee Info-7
Technical Program Committee Info-8
Panel of Reviewers Info-12

Conference Location & Floor Plan Info-13
General Information Info-14
About Kristiansand, Norway Info-15
About ICIEA Info-16
Presentation Guidelines Info-18

Keynote Speeches

Keynote I DIN SPEC 91345 RAMI4.0-based Engineering of Industrial Cyber-Physical Systems Info-22
Professor Dr.-Ing. Armando Walter Colombo, Germany

Keynote II Speech Processing at Cocktail Party Info-24
Professor Haizhou Li, Germany

Keynote III Extremum Seeking and its Applications Info-25
Professor Miroslav Krstic, USA

Technical Programme

Non-live Sessions Info-27
Abstracts 3
Author Index 146
Programme-at-a-Glance At the END

Message from The General Chairs

Zheng Guo LI
General Chair(s)

Jing ZHOU
General Chair(s)

Geir Grasmo
General Chair(s)

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 Staten's 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.

Zheng Guo LI
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Jing ZHOU
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Jianwei Niu
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Jiaqi Yan
Jiawei Cao
Jiaxing Wu
Jie Ding
Jie Hang
Jinbo Li
Jing Dai
Jing Zhang
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Jing Zhuang
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Jingbing Zhang
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Wei Hong
Wei Luo
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Wen Duan
Wenbin Dong
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XIUYI LI
Xu Huang
Xudong Ma
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Yan Xing
Yang Li
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Yilun Xu
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Ying-Chun Chuang
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Yu Ma
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Yujing Huang
Yukuan Yang
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Yunfei Zhang
Yunhong Zhou
Yunhong Zhou
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Yunlei Zhang
Yuwei Zhang
Zhanqiang Zhang
Zhao Liu
Zhaochen Li
Zhaodong Chen
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Zhixin Ou
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Zhonghai Ma
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Zijie Qi
Zilin Liang
Ziwen Xu
Ziyang Liu

Conference Location & Floor Plan

The15th 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

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 Christianssand and Christiansand, 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

About ICIEA

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 2006 — Singapore, 24–26 May 2006
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 2010 — Taichung, Taiwan, 15–17 June 2010 : http://www.ieeeiciea.org/2010
ICIEA 2011 — Beijing, China, 21–23 June 2011 : http://www.ieeeiciea.org/2011
ICIEA 2012 — Singapore, 18–20 July 2012 : http://www.ieeeiciea.org/2012
ICIEA 2013 — Melbourne, Australia, 19–21 June 2013 : http://www.ieeeiciea.org/2013
ICIEA 2014 — Hangzhou, China, 9 – 11 June 2014 : http://www.ieeeiciea.org/2014
ICIEA 2015 — Auckland, New Zealand, 15 – 17 June 2015 : http://www.ieeeiciea.org/2015
ICIEA 2016 — Heifei, China, 5-7 June 2016 : http://www.ieeeiciea.org/2016
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:

Artificial Intelligence: Natural language interaction, Text analysis, Image analysis, Video analysis, Speech recognition, Object recognition, Gesture recognition, Statistical learning, Machine learning, Deep learning, Reinforcement learning, Predictive analytics, Data analytics, Knowledge representation, Reasoning, Neural networks, AI applications, Design for AI chip and systems.

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 senses computing.

Energy and Environment: Energy management and control systems, Energy distribution, storage and recovery, Alternative and green energy, Waste management, Waste treatment and recycling, Water network and security, Sensor technologies, Intelligent micro-grids.

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.

Robotics: Robotics vision, Visual servoing, Visual servoing simulation, SLAM, LIDAR, Sensors and sensor fusion, Actuators, Motion control, Robot-human collaboration, Remote operation, Autonomous mobile robot, 3D simulation, Offline programming, AI application in robotics, Industrial application case study.

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@uia.no), Prof. Ilya Tyapin (ilya.tyapin@uia.no), Prof. Morten Kjeld Ebbesen (morten.k.ebbesen@uia.no) or Prof. Chenguang Yang (Charlie.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, industrialdigitalization and system-of-systems engineering, Internet-of-Services, Industry 4.0-compliant solutions.

Prof. Colombo has over 30 industrial patents and more than 300 per-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 advisorexpert 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 expert/evaluator 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

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-DAHZ, Germany-Argentina.

Keynote Speech II

Date/Time: November 10, 2020 (Tuesday) / 10:00 - 11:00 hrs
Venue/Room:

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:

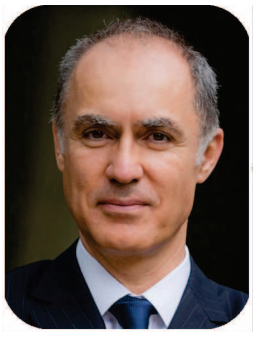
Keynote Speech III

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.

Technical Programme

Session [LS01]: Best Paper Award Selection

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 Nurmi 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[1], Stefan Jakubek[2] and Christoph Hametner[1]
[1]*Christian Doppler Laboratory for Innovative Control and Monitoring of Automotive Powertrain Systems, TU Wien, Vienna, Austria.* [2]*Institute 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

Zhengqin Xu[1], Yang Lu[1], Jiaxing Wu[1], Rui He[1], Shiqian Wu[1] and Shoulie Xie[2]
[1]*School of Machinery and Automation, Institute of Robustics and Intelligent Systems, Wuhan University of Science and Technology Wuhan, China.* [2]*Signal Processing, RF & Optical Dept., Institute for Infocomm 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[1], Sarath Kodagoda[1], Nalika Ulapane[2] and Mukesh Prasad[3]
[1]*iPipes Lab, UTS Robotics Institute, University of Technology Sydney, Sydney, Australia.* [2]*School of Electrical and Electronic Engineering, University of Melbourne, Melbourne, Australia.* [3]*Centre for Artificial Intelligence, University of Technology Sydney, Sydney, Australia.*

P1602 **Pg 4**

Model Predictive Power Control with Current Stress Optimization for Bidirectional Series Resonant DCDC Converter

Wensheng Song, Ming Zhong and Shucong 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[1], Zhang Fan[2] and Enmao Liu[3]
[1]*Department of Public Art, Beijing Institute of Fashion Technology, Beijing, China.* [2]*Department of Industrial Design, Beijing Institute of Fashion Technology, Beijing, China.* [3]*College of Computer Science and Technology, Zhejiang University, Hangzhou, China.*

P1013 **Pg 5**

Summary of Pedestrian Traffic Statistics Research

Jian Sheng[1,2,3] and Zhi Zhang[1,2,3]
[1]*Collage of Computer Science and Technology, Wuhan University of Science and Technology, Wuhan 430065, Hubei, China.* [2]*Hubei Province Key Laboratory of Intelligent Information Processing and Real-time Industrial System, Wuhan, China, 430065, Hubei, China* [3]*Big 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[1], Wilfred Kang Chee Wong[2], Kyaw Sett Myo[1] and Weng Xian Choong[1]
[1]*Advanced Remanufacturing and Technology Center (ARTC), Agency for Science, Technology and Research (A*Star), Singapore.* [2]*Singapore Polytechnic (SP), Singapore.*

P1040 **Pg 6**

Design of a Novel Device for Measuring the Inertia of Helmet

Xiao Chen[1], Cong Zhang[2], Wei Zhang[3], Chuang Ma[2] and Jianwei Niu[2]
[1]*Institute of System Engineering, Academy of Military Science, People's Liberation Army Beijing, China.* [2]*School of Mechanical Engineering, University of Science and Technology Beijing, Beijing, China.* [3]*School of Mechanical Engineering, Beihang University, Beijing, China.*

P1055 **Pg 6**

Int-Papercut: An Intelligent Pattern Generation with Papercut Style Based on Convolutional Neural Network

Enmao Liu[1], Lijuan Liu[1], Junwu Wang[2], Qiming Jin[3], Cheng Yao[1] and Fangtian Ying[1]
[1]*Collage of Computer Science and Technology, Zhejiang Unversity, Hangzhou, China.* [2]*School of Industrial Design, Hubei University of Technology, Wuhan, China.* [3]*Product Research and Development Department, Co-share Educatinal Tech Hangzhou, China.*

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

P1036 **Pg 6**

Improve Performances of a Laser Tracking System by Adopting a Modified Fuzzy Neural Network Controller

Ying Bai[1] and Dali Wang[2]
[1]*Dept. of ComputerScience and Engineering, Johnson C.Smith University, Charlotte, USA.* [2]*Dept. of Physics and Computer Science, Christopher Newport University, Newport News, USA.*

P1203 **Pg 6**

Device Target Checking for Power Patrol Robot Based on Objectness Estimation

Lili Huang, Xudong Ma, Fang Fang and Bo Zhou
Key Laboratory of Measurement and control of CSE, (School of Automation, Southeast University), Nanjing 210096, Jiangsu. P. R. China.

P1027 **Pg 7**

A Review of Intelligent Methods for Unpaved Roads Condition Assessment

Nausheen Saeed[1], Mark Dougherty[1,2], Roger G. Nyberg[1], Pascal Rebreyend[1] and Diala Jomaa[1]
[1]*Faculty of Data & Information Sciences, Dalarna University, Borlänge, Sweden.* [2]*School of Information Technology, Halmstad University, Halmstad, Sweden.*

P1015 **Pg 7**

Summary of Scene Text Detection and Recognition

Yao Qin[1,2,3] and Zhi Zhang[1,2,3]
[1]*Collage of Computer Science and Technology, Wuhan University of Science and Technology, Wuhan 430065, Hubei, China.* [2]*Hubei Province Key Laboratory of Intelligent Information Processing and Real-time Industrial System, Wuhan, China, 430065, Hubei, China.* [3]*Big Data Science and Engineering Research Institute, Wuhan University of Science and Technology, Wuhan, China, 430065, Hubei, China*

P1020 **Pg 7**

A Survey of Facial Expression Recognition Based on Deep Learning

Heng Wei[1,2,3] and Zhi Zhang[1,2,3]
[1]*Collage of Computer Science and Technology, Wuhan University of Science and Technology, Wuhan 430065, Hubei, China.*[2]*Hubei Province Key Laboratory of Intelligent Information Processing and Real-time Industrial System, Wuhan, China, 430065, Hubei, China.* [3]*Big Data Science and Engineering Research Institute, Wuhan University of Science and Technology, Wuhan, China, 430065, Hubei, China*

P1023 **Pg 8**

Automatic Generation Method of Ancient Poetry Based on LSTM

Hanshuang Zhang[1,2,3] and Zhi Zhang[1,2,3]
[1]*Collage of Computer Science and Technology, Wuhan University of Science and Technology, Wuhan 430065, Hubei, China.* [2]*Hubei Province Key Laboratory of Intelligent Information Processing and Real-time Industrial System, Wuhan, 430065, Hubei, China.* [3]*Big Data Science and Engineering Research Institute, Wuhan University of Science and Technology, Wuhan, 430065, Hubei, China*

Session [TT03]: Industrial Information & Computational Intelligence (III)

P1082 **Pg 8**

Fault Diagnosis of Subway Plug Door Based on KPCA and CS-LSSVM

Xidan Heng, Qilong Jiang, Dong Liu, Le Xie, Taoning Zhan and Ningyuan Jin
School of Electrical Engineering, Southwest jiaotong university, Chengdu, China.

P1459 **Pg 8**

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

Yang Liu[1], Dong Liu[1], ChenXi Li[1], Yiyang Wang[2], Junyao Yang[2] and Qilong Jiang[1]
[1]*School of Electrical Engineering, Southwest Jiaotong University, Chengdu, China.* [2]*Leeds Joint School, Southwest Jiaotong University, Chengdu, China.*

P1612 **Pg 8**

Adaptive Multi-Layer Structure for Anomaly Detection in Hyperspectral Images

Hongmei Yan and Mingyi He
Northwestern Polytechnical University, Xian, China, 710129.

P1273 **Pg 9**

Parameter Design and Performance Analysis of an Improved MOCEO Algorithm

Zhao Duo, Huang Chenxi, Tang Qichao and Zhang XiaYing
School of Electrical Engineering, Southwest Jiaotong University, Chengdu 610031.

P1185 **Pg 9**

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

Bihai Zou, Yujie Xiang, Rui Zou, Hong Liu, Chunbi Xu, Yu Zou and Sitong Chen
School of Safety Engineering, Chongqing University of Science and Technology, Chongqing, China.

P1143 **Pg 9**

Multicriteria Group Decision Making Approach for Evaluating the Performance of FinTech Projects

Santoso Wibowo, Lakshmi Grandhi and Srimannarayana Grandhi
School of Engineering & Technology, Cental Queensland University, Melbourne, Australia.

Session [TT04]: Industrial Informatics & Computational Intelligence (IV)

P1610 **Pg 10**

Managing SLA Violation in the cloud using Fuzzy re-SchdNeg Decision Model

Bashair Ali Alrashed[1] and Walayat Hussain[2]
[1]*Information Technology Department, Faculty of Computer Science and IT, King Abdulaziz University Jeddah, Saudi Arabia.* [2]*Faculty of Engineering and IT, University of Technology Sydney, Australia.*

P1166 **Pg 10**

Fault-Tolerant Application Mapping on to ZMesh Topology based Network-on-Chip Design

P. Veda Bhanu[1], Nikita Mandapati[1], Soumya J[1] and Linga Reddy Cenkeramaddi[2]
[1]*Department of Electrical and Electronics Engineering, BITS-Pilani, Hyderabad Campus, Hyderabad, Telangana, India 500078.* [2]*Department of Information and Communication Technology, University of Agder, Norway.*

P1568 **Pg 10**

A Densely Connected Face Super-Resolution Network Based on Attention Mechanism

Ying Liu[1], Zhanlong Dong[2], Keng Pang Lim[2] and Nam Ling[3]
[1]*Ministry of Public Security, Key Laboratory of Electronic Information Application, Technology for Scene Investigation, Xi'an Shaanxi, China.* [2]*Xi'an University of Posts & Telecommunications, Center for Image and Information Processing, Xi'an Shaanxi, China.* [3]*Santa Clara University, Department of Computer Science and Engineering, Santa Clara, CA, USA.*

P1038 **Pg 10**

Anomaly Detection of Heat Energy Usage in District Heating Substations Using LSTM based Variational Autoencoder Combined with Physical Model

Fan Zhang[1] and Hasan Fleyeh[2]
[1]*Dalarna University, Departments of Energy Technology and Microdata Analysis Falun, 79188, Sweden.* [2]*Dalarna University, Department of Computer Engineering, Falun, 79188, Sweden.*

P1497 **Pg 11**

A Review on Data Analysis of Bitcoin Transaction Entity

He Xi[1], Zhang Fan[2], Lin Shenwen[3], Mao Hongliang[3] and He Ketai[1]
[1]*School of Mechanical Engineering, University of Science and Technology Beijing, Beijing, China.* [2]*School of Computer & Communication, Engineering, University of Science and Technology Beijing, Beijing, China.* [3]*National Computer Network, Emergency Response Technical, Team/Coordination Center of China, Beijing, China.*

P1501 **Pg 11**

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

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

P1520 **Pg 11**

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.

P1221 **Pg 12**

Health Status Evaluation of Intelligent Power Distribution Room based on AHP- Entropy method

JunPing Luo[1], GuangHui Sun[2], Chao Shang[3], LingSen Chen[3], Bin Li[3] and Jun He[3]
[1]*China Southern Power Grid, GuangZhou, China.* [2]*China Southern Power Grid, Guangdong Power Grid Corporation, GuangZhou, China.* [3]*China Southern Power Grid, Digital Grid Research Institute, GuangZhou, China.*

P1193 **Pg 12**

An Indoor Positioning Approach Using Smartphone Based on PDR and EKF

Xianshan Li, Yurun Shao and Fengda Zhao
College of Information Science and Engineering, Yanshan University, Qinhuangdao, China.

P1513 **Pg 12**

Research on RLGA-based Hardware Evolution Optimization Technology

Min Zhu[1], Sheng Yi[1], Chunling Yang[1] and Rongwei Feng[2]
[1]*Harbin Institute of Technology, School of Electrical Engineering, Harbin, China.* [2]*Beijing Orient Institute of Measurement and Test, Beijing, China.*

P1525 **Pg 12**

Research on Task Decompsition and Optimization Methods of Cyber Physical Systems

Xiaodong Wang, Yangming Guo, Huan Yang, Zhuqing Wang, Yuan Li, Nan Lu, Yan Zhang and Zhiyu Zou
School of Computer Science, NorthWestern Polytechnical University, Xi'an, China

P1595 **Pg 13**

Numerical Modeling of the Effects of Electrode Spacing and Multilayered Concrete Resistivity on the Apparent Resistivity Measured Using Wenner Method

Karthick Thiyagarajan, Parikshit Acharya, Lasitha Piyathilaka and Sarath Kodagoda
iPipes Lab, UTS Robotics Institute, Faculty of Engineering and Information Technology, University of Technology Sydney, Sydney, Australia.

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

P1631 **Pg 13**

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 Sturt University, Australia.

P1633 **Pg 13**

Image Encryption Based on Fractional-Order Chen Hyperchaotic System

Jun Peng[1,2], Wu Yang[2], Shangzhu Jin[1], Shaoning Pang[3], Dedong Tang[4], Junjie Bai[4] and Du Zhang[5]
[1]*School of Intelligent Technology and Engineering Chongqing University of Science and Technology, Chongqing 401331, China.* [2]*School of Computer Science and Engineering Chongqing University of Technology, Chongqing 400054, China.* [3]*School of Science, Engineering and Information Technology Federation University Australia, Ballarat, Victoria, Australia.* [4]*School of Electrical Engineering, Chongqing University of Science and Technology, Chongqing 401331, China.* [5]*Faculty of Information Technology, Macau University of Science and Technology, Macau, China.*

P1279 **Pg 14**

Research on Task-Oriented Dynamic Reconstruction Method of UAV Swarm Evolutionary Game

Huan Yang, Yangming Guo, Xiaodong Wang, Hongjing Yao, Zhuqing Wang and Geng Li
School of Computer Science, NorthWestern Polytechnical University, Xi'an, China.

P1309 **Pg 14**

Low-Cost Air Quality Sensing Process: Validation by Indoor-Outdoor Measurements

Naser Hossein Motlagh[1], Martha Arbayani Zaidan[2], Pak L. Fung[2], Xinyang Li[2], Yutaka Matsumi[3], Tuukka Petäjä[2], Markku Kulmala[2], Sasu Tarkoma[1] and Tareq Husseinz[2,4]
[1]*Department of Computer Science, University of Helsinki, Finland.* [2]*Institute for Atmospheric and Earth System Research (INAR), University of Helsinki, Finland.* [3]*Institute for Space-Earth Environmental Research (ISEE), Nagoya University, Japan.* [4]*Department of Physics, Faculty of Science, University of Jordan, Amman, Jordan.*

P1019 **Pg 14**

Path Planning System for Smart Cars Used in Education

Guangyu Xiong[1,2], Lulu Niu[3,4], Yanfu Tian[1], Jiehan Zhou[5], Babak Mohajeri[6] and Timo R. Nyberg[6]
[1]*Silk Road Business School, Sanya University (USY), Hainan, China.* [2]*The Guangdong Engineering Research Center of 3D Printing and Intelligent Manufacturing, The Cloud Computing Center, Chinese Academy of Sciences, Dongguan, China.* [3]*School of Articial Intelligence, University of Chinese Academy of Sciences, Beijing, China.* [4]*State Key Laboratory for Management and Control of Complex Systems, Institute of Automation, Chinese Academy of Sciences, Beijing, China.* [5]*University of Oulu, Oulu, Finland.* [6]*Department of Industrial Engineering and Management, Aalto University, Espoo, Finland.*

P1026 **Pg 15**

Improving Sustainability in the Value Chain of the Apparel Industry Empowered with Social Manufacturing

Babak Mohajeri[1], Ilkka Kauranen[1], Timo Nyberg[1], Elina Ilen[2], Mark Nelson[3] and Gang Xiong[4]
[1]*Aalto University, Department of Industrial Engineering and Management, Helsinki, Finland.* [2]*Aalto University, School of Arts, Design and Architecture Helsinki, Finland.* [3]*Human Sciences and Technologies, Advanced Research Institute (H-STAR), Stanford University, USA.* [4]*Beijing Engineering Research Center of Intelligent Systems and Technology, Institute of Automation, & Cloud Computing Center, Chinese Academy of Sciences, China.*

Session [TT07]: Control and Systems (I)

P1202 **Pg 15**

Boundary Learning for Spark-Ignition Engine Control

Kai Zhao and Tielong Shen
Department of Engineering and Applied Sciences, Sophia University, Tokyo, Japan.

P1216 **Pg 15**

Inertia Estimation for PMSM Drive System Using Artificial Neural Network

Chengbo Yang, Bao Song, Xiaoqi Tang and Yuanlong Xie
State Key Laboratory of Digital Manufacturing Equipment and Technology, School of Mechanical Science and Engineering, Huazhong University of Science and Technology, Wuhan, China.

P1619 **Pg 16**

Adaptive Robust Control of the Cable Driven System for Position Tracking

Bin Li[1], Liang Yan[1], Liqin Zhang[1] and Christopher Gerada[2]
[1]*School of Automation Science and Electrical Engineering, Beihang University, Beijing, China.* [2]*Department of Electrical and Electronic Engineering, University of Nottingham, Nottingham, UK.*

P1001 **Pg 16**

DFIG Pitch Angle Control with PID-type Fuzzy Logic Controller in a Microgrid

Ujjwal Datta[1], Juan Shi[1], Akhtar Kalam[1] and Jiangrong Li[2]
[1]*College of Engineering and Science, Victoria University, Victoria 8001, Melbourne, Australia.* [2]*College of Mathematics and Computer Science, Yan'an University, Yan'an, 716000, P. R. China.*

P1209 **Pg 16**

Online Optimal Control for Nonlinear Fin Stabilizer System of Marine Vessels via Time-based ADP Algorithm

QuangDuy Nguyen[1,2], Tieshan Li[1,3], Jun Ning[1] and Yue Wu[1]
[1]*Navigation College, Dalian Maritime University, Dalian, Liaoning, China.* [2]*Faculty of Navigation, Vietnam Maritime University, Haiphong, Vietnam.* [3]*School of Automation Engineering, University of Electronic Science and Technology of China, Chengdu, Sichuan, China.*

P1116 **Pg 16**

An Efficient Motion Trajectory Planning Method in CNC System

Yanshu Lang[1,2], Dong Yu[1], Wenye Han[1] and Shujie Sun[1,3]
[1]*Shenyang Institute of Computing Technology, Chinese Academy of Sciences, Shenyang, Liaoning, P. R. China, 110168.* [2]*University of Chinese Academy of Sciences, Chinese Academy of Sciences, Beijing, P. R. China, 100049.* [3]*School of Electromechanical and Automotive Engineering, Yantai University, Yantai, Shandong Province, China.*

Session [TT08]: Control and Systems (II)

P1232 **Pg 17**

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

Faa-Jeng Lin, Shih-Gang Chen and Chia-Hui Liang
Dept. of Electrical Engineering, National Central University, Chungli, Taiwan.

P1274 **Pg 17**

An Efficient Feedrate Dynamic Planning Method in CNC System

Yanshu Lang[1,2], Dong Yu[1], Wenye Han[1], Shujie Sun[1,3] and Mingxia Li[1,2]
[1]*Shenyang Institute of Computing Technology, Chinese Academy of Sciences, Shenyang, Liaoning, P. R. China, 110168.* [2]*University of Chinese Academy of Sciences, Chinese Academy of Sciences, Beijing, P. R. China, 100049.* [3]*School of Electromechanical and Automotive Engineering, Yantai University Yantai, Shandong Province, China.*

P1331 **Pg 17**

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

Abdoulaye Dieng[1] and Jean-Claude Le Claire[2]
[1]*University of Cheikh Anta Diop, de Dakar – ESP Laboratory LER, Dakar, Senegal.* [2]*University of Nantes – IREENA, Institut de Recherche en Energie, Electrique de Nantes Atlantique, Saint-Nazaire cedex, France.*

P1118 **Pg 18**

INTSMC-Based Fault Tolerant Control Approach for a 2-DOF Robotic System

Yashar Shabbouei Hagh[1], Reza Mohammadi Asl[1], Afef Fekih[2] and Heikki Handroos[1]
[1]*Laboratory of Intelligent Machines, LUT University, Lappeenranta, Finland.* [2]*Department of Electrical and Computer Engineering, University of Louisiana at Lafayette, Lafayette, USA.*

P1220 **Pg 18**

A New Approach to Development and Validation of Artificial Intelligence Systems for Drilling

Jan Einar Gravdal[1], Robert Ewald[2], Nejm Saadallah[2], Sonja Moi[2], Dan Sui[3] and Roman Shor[4]
[1]*NORCE-Norwegian Research Center, Drilling and Well Modeling Group, and University of Stavanger, Bergen/Stavanger, Norway.* [2]*NORCE-Norwegian Research Center, Drilling and Well Modeling Group Stavanger, Norway.* [3]*University of Stavanger, Department of Energy and Petroleum Engineering, Stavanger, Norway.* [4]*University of Calgary, Department of Chemical and Petroleum Engineering, Calgary, Canada.*

P1313 **Pg 18**

Optimal Control Design for a Group of Mobile Robots with Uncertainties

Askhat Diveev and Elizaveta Shmalko
Department of Robotics Control, FRC CC RAS, Moscow, Russia.

Session [TT09]: Control and Systems (III)

P1044 **Pg 18**

Fault Identification for Systems Described by Nonlinear Models Using Sliding Mode Observers

Alexey Zhirabok[1], Alexander Zuev[2] and Alexey Shumsky[3]
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P1145 **Pg 19**

Modeling and Analysis of Sensor Uncertainty for Non-Iterative Air Balancing Methods

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P1487 **Pg 19**

A New Sliding Mode Control Method for Discrete Network System with Bilateral Delay

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P1016 **Pg 19**

Stabilization of Nonlinear Networked Switched Control Systems with Delays and Packet Losses

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P1435 **Pg 19**

Unbalanced Voltage Control of Bipolar DC Microgrid Based on Distributed Cooperative Control

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P1349 **Pg 20**

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

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Session [TT10]: Control and Systems (IV)

P1444 **Pg 20**

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

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P1179 **Pg 20**

Multi-Tasking Syetem Design for Multi-Axis Synchronous Control of Robot Based on RTOS

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P1301 **Pg 21**

Planning Method of Transportation and Power Coupled System Based on Road Expansion Model

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P1197 **Pg 21**

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

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P1468 **Pg 21**

A SMO Based Position Sensorless Permanent Magnet Synchronous Motor Control Strategy

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P1540 **Pg 21**

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

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Session [TT11]: Energy and Environment (I)

P1172 **Pg 22**

Energy Management Method for Hybrid Energy Storage Tram Based on Equivalent Loss Instantaneous Optimization

Chaohua Dai, Qin Zhang, Zhentao Yang, Yun Du, Fangli Shi and Jiayi Liang
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P1095 **Pg 22**

Energy Management Strategy Based on a New Adaptive Filtering Algorithm for Battery-Ultracapacitor Electric Vehicles

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P1284 **Pg 22**

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

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P1285 **Pg 23**

An Advanced Traction Power Supply System in Electrified Railway

Yilin Cheng, Minwu Chen, Zhe Cheng and Ruofei Liu
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P1606 **Pg 23**

Virtual Inertia Adaptive Control Strategy for DFIG Wind Turbines Based on Exponential Function

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P1233 **Pg 23**

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

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Session [TT12]: Energy and Environment (II)

P1524 **Pg 23**

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

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P1590 **Pg 24**

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

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P1155 **Pg 24**

Energy Storage System as Auxiliaries of Internal Combustion Engines in Hybrid Electric Ships

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P1464 **Pg 24**

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

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P1512 **Pg 25**

Uncertainty Analysis of Wind Power Based on Levelized Cost of Energy

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P1171 **Pg 25**

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

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Session [TT13]: Energy and Environment (III)

P1515 **Pg 25**

Honeycomb Active Distribution Network: A Novel Structure of Distribution Network and Its Stochastic Optimization

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P1293 **Pg 26**

Review on Reliability Evaluation of Urban Integrated Energy System based on Multi-Source Data

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P1110 **Pg 26**

An Easy-to-Characterize Electrochemical Model for Lithium-Ion Batteries and Its Metaheuristic Parametrization

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P1021 **Pg 26**

Intrinsic Thermal Couples for Measurement in High Temperature and High Heat Flux Environment

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P1467 **Pg 26**

Stochastic Model Predictive Control for the Yaw Control System of Horizontal-Axis Wind Turbines

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P1108 **Pg 27**

Multi-Objective Capacity Optimization of Integrated Energy System with Compressed Air Energy Storage

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Session [TT14]: Energy and Environment (IV)

P1099 **Pg 27**

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

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P1109 **Pg 27**

An Ultra-Short-Term Prediction Method for Wind Speed Series based on Gaussian Process Median Regression

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P1246 **Pg 27**

Variable Time Constant Smoothing Strategy Based on Wind Power Flattening Index

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P1458 **Pg 28**

Research on SOC Estimation of Lithium Battery based on GWO-BP Neural Network

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P1463 **Pg 28**

Lithium Battery SOC Estimation Based on Improved Unscented Kalman Filter

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P1317 **Pg 28**

Optimal Rural Integrated Energy System Configuration against the Background of the Rural Energy Transformation Strategy

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Session [TT15]: Robotics (I)

P1623 **Pg 29**

Stereo Refinement Based on Gradient Domain Guided Filtering

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P1150 **Pg 29**

Image Based Visual Servoing for Landmine Detection using Quadrotors

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P1320 **Pg 29**

Dynamic Augmented Kalman Filtering for Human Motion Tracking under Occlusion Using Multiple 3D Sensors

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P1101 **Pg 29**

Humanoid Muscle-Skeleton Robot Arm Design and Control Based on Reinforcement Learning

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P1295 **Pg 30**

Guidelines to Select Between Self-Contained Electro-Hydraulic and Electro-Mechanical Cylinders

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P1413 **Pg 30**

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

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P1323 **Pg 30**

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

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Session [TT16]: Robotics (II)

P1102 **Pg 30**

A Sign Language Interaction System Based on Pneumatic Soft Hand

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P1421 **Pg 31**

An Adaptive Backstepping Control Method for Lower-Limb Exoskeleton Robot

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P1187 **Pg 31**

Application of Image-Based Visual Servoing on Autonomous Drones

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P1267 **Pg 31**

A Agricultural Spraying and Fertilization Robot based on Visual Navigation

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P1567 **Pg 32**

A Brief Survey: Deep Reinforcement Learning in Mobile Robot Navigation

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P1298 **Pg 32**

Navigation Path Curve Extraction Method Based on Depth Image for Combine Harvester

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Session [TT17]: Robotics (III)

P1178 **Pg 32**

Trajectory Sampling and Fitting Restoration Based on Machine Vision for Robot Fast Teaching

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P1189 **Pg 33**

A Wearable Body Motion Capture System and Its Application in Assistive Exoskeleton Control

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P1270 **Pg 33**

A Bio-inspired Spiking Neural Network for Control of A 4-DoF Robotic Arm

Xinyi Chen, Wenxin Zhu, Yunxiang Dai and Qinyuan Ren
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P1611 **Pg 33**

Controlled Propulsion of Asymmetric Janus Microdimer Swimmers under Rotating Magnetic Fields

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Session [TT18]: Power Electronics (I)

P1115 **Pg 33**

Study on Temperature Rise Test of Valve Bridge Arm Reactor for VSC-HVDC System Based on Equivalent Loss

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P1339 **Pg 34**

Winding Temperature Analysis of 3-D Wound Core Transformer Under Overload and Short-Circuit Conditions

Jiazhu Xu, Jie Zhou, Yaqian Yang and Jing Xia
College of Electrical and Information Engineering, Hunan University, Changsha, China.

P1408 **Pg 34**

A Non-Contact SiC Power MOSFETs Health Status Monitoring Method Based on Magnetic Field Detection Technology

Jiuzhu Zhang, Mingyao Ma, Na Meng, Weisheng Guo, Shuying Yang and Xing Zhang
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P1500 **Pg 34**

250kW High-Frequency Transformer Design and Verification for MVDC Collection System for Renewable Energy Resources

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P1597 **Pg 35**

An Optimized Fault Feature Extraction Method for PV Grid-Connected T-Type Three Level Inver

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P1107 **Pg 35**

Enhancing Short Circuit Ruggedness of 1.7 kV IGBTs using a Gate-Source-Shorted Depletion-Mode MOSFET in Series with the Emitter

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Session [TT19]: Power Electronics (II)

P1031 **Pg 35**

A Paralleled SiC MOSFET Half-bridge Unit With Distributed Arrangement of DC Capacitors

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P1306 **Pg 35**

Rotating Power Electronics for Electrical Machines and Drives - Design Considerations and Examples

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P1402 **Pg 36**

Research on Power Electronic Transformers Based on Virtual Synchronous Machine Control

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P1453 **Pg 36**

DC Solid State Circuit Breaker Based On GaN

Qian Kong, Songrong Wu, Feihu Zhang, Ping Yang, Yang Zhou and Jiaxin Wei
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P1618 **Pg 36**

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

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P1175 **Pg 36**

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

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Session [TT20]: Power Electronics (III)

P1204 **Pg 37**

Simulation of Photovoltaic Absorption Strategy for Distribution Network Considering Translational Load

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P1296 **Pg 37**

Power-Based Phase-Locked Loops for Single-Phase Applications — A Survey

Hao Qian, Jinming Xu[a] and Shaojun Xie
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P1394 **Pg 37**

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

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P1403 **Pg 38**

Research on UPS Filter Based on Passive Damping and Harmonic Trap

Haichun Liu, Hong Cao and Shaojun Xie
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P1518 **Pg 38**

Research on Control Strategy of Photovoltaic Grid Connected Converter Under Voltage Distortion

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P1061 **Pg 38**

Analysis of Id-Iq Strategy for Active Power Filter

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Session [TT21]: Power Electronics (IV)

P1433 **Pg 39**

Analysis of Energy Feed System of Metro under Adaptive Moment of Inertia VSG Control

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P1322 **Pg 39**

A Cost-Effective Controlled-Type ZVS Technique for GaN-Based Totem-Pole PFC Rectifier

Liu Yang, Xinyu Xu, Yihang Jia, Yue Liu, Yu Tai, Hongfei Wu and Yan Xing
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P1265 **Pg 39**

Controlled Three-Phase LCL- Filter PWM Rectifier with BESS-oriented Applications Under Unbalanced Grid Conditions

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P1325 **Pg 39**

Microcontroller-Based Implementation of a Direct AC-AC SPWM Power Converter

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P1434 **Pg 40**

A Resonant DAB DC-DC Converter Using Dual Transformers With Wide Voltage Gain And Variable Switching Frequency

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P1456 **Pg 40**

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

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Session [TT22]: Power Electronics (V)

P1471 **Pg 40**

ANPC Three-level Model Predictive Control Strategy Without Weight Factor

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P1476 **Pg 40**

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

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P1541 **Pg 41**

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

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P1563 **Pg 41**

Performance Evaluation of LC-L Resonant Converter with Integrated Magnetics

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P1009 **Pg 41**

A New Wideband Modeling Method of Converter Transformer

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P1160 **Pg 42**

An Improved Human-Simulated Intelligent Control Algorithm for Bidirectional DC-DC Converter

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Session [TT23]: Power Electronics (VI)

P1249 **Pg 42**

Small-Signal Modeling of CLLC Bidirectional Resonant Converters

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P1251 **Pg 42**

Analysis and Optimization of Single-Phase T-Type BCM Microinverter

Chengzhi Wan, Lei Li and Jinchuan Zhang
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P1268 **Pg 42**

Hybrid Modulation Interleaving Scheme for CRM Totem-Pole Bridgeless PFC Rectifier

Jinchuan Zhang, Lei Li and Xin Zhang
College of Automation, Nanjing University of Science and Technology, Nanjing, China.

P1333 **Pg 43**

A Step-Up Switched Capacitor Multilevel Inverter with Reduced Switches Tolerating Lower Stress

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College of Automation, Nanjing University of Science and Technology, Nanjing, China.

P1509 **Pg 43**

A Virtual Resistor Control Scheme for Boost Converter

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P1281 **Pg 43**

Optimization Design of Doubly Salient Electro-Magnetic Motor under Fault-Tolerant Operation of Excitation Fault

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Session [TT24]: Power Electronics (VII)

P1042 **Pg 43**

High-Frequency Signal Injection using Extend State Observer for Position Sensorless PMSM Drives

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P1053 **Pg 44**

Fundamental PWM Excitation Based Low-Speed Sensorless Control Method for PMSM Drives

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P1205 **Pg 44**

Economic Optimization Model of Islanded Microgrid Considering the Benefit of Energy Storage Charge and Discharge

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P1282 **Pg 44**

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

Beibei Liu, Jian Yang, Wendong Feng, Ya Li, Lingqi Fang and Quanxu Lv
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P1422 **Pg 44**

New Design and Implementation of Power Distribution Network Management System

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P1111 **Pg 45**

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

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

Session [TT25]: Power Electronics (VIII)

P1496 **Pg 45**

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

Fang Liu, Shiquan Liu, Meng Wang, Zhe Zhang and Haodong Wang
School of Electrical Engineering and Automation, Hefei University of Technology, Hefei, China.

P1511 **Pg 45**

A Method for Calculating the Impedance of Threephase Transformer in Photovoltaic Power Station Based on Power Loss

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P1208 **Pg 46**

Performance Analysis and Comparison of Two Kinds of Double-Layer Permanent Magnet Synchronous Motors

Xin Chen[1], Guoli Li[1], Zhe Qian[1], Qunjing Wang[1], Jian Zhou[1,e] and Yi Cheng[2]
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P1414 **Pg 46**

Research on Impact of Distributed Photovoltaic Grid Connection on Three-section Current Protection Strategy of Distribution Network

Xiaochen Ma, Yunhua Li and Liman Yang
School of Automation Science and Electrical Engineering Beihang University, Beijing 100191, China.

P1615 **Pg 46**

A Two-stage Model Predictive Control Strategy for Economical Operation of Microgrid

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P1192 **Pg 46**

Stiction Fault in MEMS Comb Drive Resonator

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P1244 **Pg 47**

Research for Micro Energy Pulse Power Supply Used by Combination Electro-discharge Machining

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Session [TT26]: Power Electronics (IX)

P1588 **Pg 47**

Simulation Based Method to Characterize Parasitic Parameters in a Double Pulse Test System

Jianzhen Qu, Xue Yuan, Qianfan Zhang and Shumei Cui

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P1583 **Pg 47**

Voltage Control of Bipolar DC Distribution Systems Considering the Characteristics of Constant Power Load: A Load-Side Solution

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P1051 **Pg 48**

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

Shuangcheng Song, Zhihao He, Xi Zhang and Qianfan Zhang
School of Electrical Engineering and Automation, Harbin Institute of Technology, Harbin, China.

P1291 **Pg 48**

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

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P1238 **Pg 48**

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

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P1304 **Pg 48**

Optical Method Based Detection and Wavelets Based Processing of Acoustic Waves

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

P1057 **Pg 49**

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

Zewen Yang[1], Lu zhang[1], Ning Lv[1], Shuang Chen[1], Zhiyuan Tang[1], Huijun Wang[1,f], Lele Luo[2] and Li Yuan[3]
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P1598 **Pg 49**

Dynamic Regret Analysis for Online Tracking of Time-varying Structural Equation Model Topologies

Bakht Zaman, Luis Miguel Lopez Ramos and Baltasar Beferull-Lozano
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P1469 **Pg 49**

Multi-Scale Ship Tracking Based On Maritime Monitoring Platform

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P1470 **Pg 50**

A Novel Method based on Character Segmentation for Slant Chinese Screen-render Text Detection and Recognition

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P1146 **Pg 50**

Sleeper Defect Detection Based on Improved YOLO V3 Algorithm

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P1151 **Pg 50**

Detection Method of Track Locating Point Based on Yolo V3

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Session [TT28]: Signal and Information Processing (II)

P1292 **Pg 51**

GPU-Based Occlusion Minimisation for Optimal Placement of Multiple 3D Cameras

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P1058 **Pg 51**

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

Lu Zhang[1], Zhiyuan Tang[1], He Yang[1], Zewen Yang[1], Shuang Chen[1,e], Ning Lv[1], Huijun Wang[1], Xiaorong Shen[1], Yingzhe Tu[1] and Li Yuan[2]
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P1056 **Pg 51**

A Dual-Channel Design in Microfluidic Chip for Label-Free Detection by Quasi-Bessel Beam

Ning Lv[1], Lu zhang[1], Zewen Yang[1], Lili Jiang[1], Amir Muhammad[1], Zhiyuan Tang[1], Huijun Wang[1] and Li Yuan[2]
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P1098 **Pg 51**

Study on Soft Sensing Technology of Penicillin Fermentation Based on PLS and SVR

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P1097 **Pg 52**

GNSS Receiver Satellite Selection Algorithm Based on Particle Swarm Optimization

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P1223 **Pg 52**

A Detection Model for Anomaly on ADS-B Data

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Session [TT29]: Signal and Information Processing (III)

P1022 **Pg 52**

Damage Identification of a Jacket Support Structure for Offshore Wind Turbines

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P1437 **Pg 53**

System Identification of Static Nonlinear Elements: A Unified Approach of Active Learning, Over-Fit Avoidance, and Model Structure Determination

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P1621 **Pg 53**

Safety Distance of Facilities and Personnel in Shale Gas Production Wellsite

Hong Liu[1], Bolong He[1], Baizhong Hu[2], Ye Zhang[3], Xiaobin Xiong[1], Zujie Bie[1], Yichen Zhang[2] and Xueyan Zhang[1]
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P1029 **Pg 53**

Signal Processing Techniques for Nonlinear Identification of Structures Using Transient Response

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P1370 **Pg 54**

Development of Portable Balance Rate Tester for Sucker Rod Pumping Unit

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P1439 **Pg 54**

Radar Emitter Signal Sorting Method Based on Density Clustering Algorithm of Signal Aliasing Degree Judgment

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Session [TT30]: Signal and Information Processing (IV)

P1630 **Pg 54**

Detection of Major Depressive Disorder using Signal Processing and Machine Learning Approaches

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P1542 **Pg 54**

Image Reconstruction using RAPID Algorithm with Time-Frequency Analysis

Josue Alvarez Lares and Qing Wang
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P1553 **Pg 55**

Denoising Method for Ultrasonic Flaw Echo Based on EMD and Local Entropy

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P1562 **Pg 55**

Research on Vehicle Logistics Terminal Design

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P1364 **Pg 55**

Design and Implementation of the Anti-Noise High Precision Voltage/Current Data Acquisition System

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P1119 **Pg 55**

Global Optimization based on Mixed H2 and H inf; Approach for Placement of Piezoelectric Actuators and Sensors on Curved Surfaces in Actively Controlled Structures

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Session [TT31]: Network and Communication Technologies

P1153 **Pg 56**

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

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P1167 **Pg 56**

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

P. Veda Bhanu[1], Vibhor Govil[1], Samala Jagadeesh[1], Soumya J[1] and Linga Reddy Cenkeramaddi[2]
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P1297 **Pg 56**

Research on Visual Performance Evaluation Model of E-commerce Websites

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P1054 **Pg 57**

A Comparative Study of Energy-Aware Routing of Wireless IoT for Intelligent Gas Metering

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Session [TT32]: Artificial Intelligence (I)

P1575 **Pg 57**

Channel-Wise Part-Based Weighting Aggregation for Image Retrieval

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P1186 **Pg 57**

Improving Black Box Classification Model Veracity for Electronics Anomaly Detection

Ana Elsa Hinojosa Herrera, Chris Walshaw and Chris Bailey
School of Computing & Mathematical Sciences, University of Greenwich, London, United Kingdom.

P1228 **Pg 58**

Detecting and Tracing Multi-Strategic Agents with Opponent Modelling and Bayesian Policy Reuse

Hao Chen, Jian Huang, Quan Liu, Chang Wang and Hanqiang Deng
College of Intelligence Science and Technology, National University of Defense Technology, Changsha, China.

P1634 **Pg 58**

A Cognitive Analytics based Approach for Machine Health Monitoring, Anomaly Detection, and Predictive Maintenance

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P1532 **Pg 58**

Indoor Space Classification Using Cascaded LSTM

Rohan Kumar Yadav, Bimal Bhattarai, Lei Jiao, Morten Goodwin and Ole-Christoffer Granmo
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P1629 **Pg 58**

Deep Learning Based Binary Classification for Alzheimer's Disease Detection using Brain MRI Images

Emtiaz Hussain[1], Mahmudul Hasan[1], Syed Zafrul Hassan[1], Tanzina Hassan Azmi[1], Md Anisur Rahman[2] and Mohammad Zavid Parvez[1]
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P1198 **Pg 59**

Grapheme to Phoneme Conversion of Norwegian using Hidden Markov Models

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Session [TT33]: Artificial Intelligence (II)

P1452 **Pg 59**

Research on Fault Diagnosis of Flight Control System Based on SVM Optimization

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P1556 **Pg 59**

Transfer Learning in General Lensless Imaging through Scattering Media

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P1182 **Pg 60**

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

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P1211 **Pg 60**

Distant Supervision Relation Extraction Model Based on Feature-recalibration Networks

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P1582 **Pg 60**

Hyper-Parameter Initialization for Squared Exponential Kernel-based Gaussian Process Regression

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P1213 **Pg 61**

CFCSS : Based on CF Network Convolutional Seq2Seq Model for Abstractive Summarization

Qingmin Liang, Tianji Chang, Ling Lu and Wu Yang
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P1264 **Pg 61**

Automatic Solving of Stabilization System Synthesis Problem by the Network Operator Method

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Session [SS01]: Invited Session on Autonomous vehicle state-of-the-art, challenges and future road map & Invited Session on Distributed Renewable Energies: Modeling, Planning, Regulation and Application

P1303 **Pg 61**

Autonomous Mooring towards Autonomous Maritime Navigation and Offshore Operations

Ajit Jha, Dipendra Subedi, Per-Ove Løvsland, Ilya Tyapin, Linga Reddy Cenkeramaddi, Baltasar Lozano and Geir Hovland
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P1490 **Pg 62**

Camera-LiDAR Data Fusion for Autonomous Mooring Operation

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P1499 **Pg 62**

A Survey on Sensors for Autonomous Systems

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P1131 **Pg 62**

Research on Calculation Method of Line Loss in Distributed Transformer Area Considering Uncertainty of Distributed Photovoltaic Output

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P1132 **Pg 62**

Design and Application of a Photovoltaic-Energy Storage Joint System with Active Frequency Regulation Capability

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P1559 **Pg 63**

Mechanism Analysis of Power Grid Cascading Failures Based on Data Mining Algorithm

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Session [SS02]: Invited Session on Advanced Control Technologies For Power Electronics and Applications

P1218 **Pg 63**

Feasibility Analysis of Energy Storage System as Black-start Power Sources for Power Grid

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P1294 **Pg 63**

A Novel Adaptive Stabilization Strategy for Autonomous DC Microgrids

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P1321 **Pg 63**

Optimal Modeling of Integrated Energy Demand Response under Time-Shared Electricity Price

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P1327 **Pg 64**

An Optimal Allocation Method for Multi-Agent Joint Capacity of Microgrid

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P1328 **Pg 64**

Control Strategy for Fast Frequency Modulation of Regional Power Grid with Energy Storage System

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P1379 **Pg 64**

Distributed Nonconvex Economic Dispatch Algorithm for Large-Scale Power System

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P1314 **Pg 65**

Lyapunov Based Current Control Scheme for Grid-Connected Inverter

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Session	[SS03]: Invited Session on Power Converters for Energy Router: Topologies, Advanced Control Strategies and Applications

P1329 **Pg 65**

Power Flow Analysis of Three-Port Resonant DC Transformer And Discussion on Phase Shift Control

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P1330 **Pg 65**

I&I Adaptive Based Backstepping Passive Coordination Control of STATCOM and Generator Excitation

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P1332 **Pg 66**

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

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P1407 **Pg 66**

Event-Triggered Model Predictive Control for A Three-Phase Inverter with Output *LC* Filter

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P1449 **Pg 66**

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

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P1523 **Pg 67**

Design and Implementation of Charging Pile in a Router-type DC Charging Station

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

P1125 **Pg 67**

Adaptive Control of a Voltage-Controlled Magnetic Levitation System with K-filter

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P1135 **Pg 67**

Fault Detection, Isolation and Estimation for Linear Systems with Partial Disturbance Decoupling

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P1147 **Pg 68**

Adaptive Fuzzy Finite-time Control for Switched Nonlinear Inverted Pendulum Systems

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P1177 **Pg 68**

Self-Triggered Control for Nonlinear Systems: A New Design Scenario From the Control Signal Perspective

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P1240 **Pg 68**

Terminal Sliding Mode Control for Spatial Descent of a Stratospheric Airship

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Session [SS05]: Invited Session on Advanced Control Methodologies for Uncertain Dynamical Systems with Industrial Applications (II)

P1286 **Pg 68**

Event-Based Formation Control for Linear Multi-Agent Systems Under Switching Topology

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P1289 **Pg 69**

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

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P1552 **Pg 69**

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

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P1620 **Pg 69**

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

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P1275 **Pg 69**

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

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Session [SS06]: Invited Session on Advanced Control and Topology for Railway Traction Drive System

P1128 **Pg 70**

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

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P1130 **Pg 70**

Improved Imaginary Axis Current Estimation for Single-phase Voltage Source Converters

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P1136 **Pg 70**

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

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P1194 **Pg 71**

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

Wenqi Deng, Jingchun Huang and Qinghua Zhang
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P1252 **Pg 71**

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

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P1254 **Pg 71**

Study on Direct Thrust Control of Six-Phase PMSLM Based on Independent H-Bridge Inverters

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P1608 **Pg 71**

Pre-Synchronization Control of Grid-Connected Three-Phase Inverters Based On the Characteristics of Synchronous Generators

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Session [SS07]: Invited Session on Power Electronics Application Technologies in Rail Transit: Intelligent Interface Design, Advanced Control Strategies, Modelling and Reliability

P1224 **Pg 72**

Modeling and Simulation of Straddle-type Monorail Vehicle Adhesion Control

Song Wang, Qiang Li, Jingchun Huang, Pengfei Sun and Qingyuan Wang
School of Electrical Engineering, Southwest Jiaotong University, Chengdu, China.

P1231 **Pg 72**

Synthesis and Analysis of Power Management Units for IoT Applications

Xi Chen, Ping Yang and Yusheng Peng
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P1250 **Pg 72**

Open-Circuit Fault Diagnosis in Shunt Active Power Filters with No Additional Sensors

Yujia Liu, Pengcheng han, Xiaoqiong He, Zeliang Shu and Shibin Gao[e]
School of Electrical Engineering, Southwest Jiaotong University, Chengdu, China.

P1258 **Pg 72**

A DC-link Oscillation Suppression Strategy in Metro Traction Drive System Based on Virtural Damping Resitor

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P1383 **Pg 73**

Formal description and verification of vehicle-to-ground communication protocol for guided transport control system

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P1455 **Pg 73**

IGBT Open-Circuit Fault Diagnosis of Single-Phase Cascade NPC Rectifiers Based on Residual Rate

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

P1065 **Pg 73**

Machine OEE Monitoring and Analysis for a Complex Manufacturing Environment

Junhong Zhou, Yu Wang and Yong Quan Chua
Singapore institute of manufacturing (SIMTech), Singapore

P1369 **Pg 74**

MVmed: Fast Multi-Object Tracking in the Compressed Domain

Lukas Bommes, Xinlin Lin and Junhong Zhou
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P1506 **Pg 74**

Smart Pegging and Release Control for Multi-product Production Testbed with Shopfloor Visibility

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P1534 **Pg 74**

Unsupervised Probability Matching for Quality Estimation with Partial Information in a Multiple-Instances, Single-Output Scenario

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P1423 **Pg 74**

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

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Session	[SS09]: Special Session on Advanced Mechatronics in Offshore Systems

P1164 **Pg 75**

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

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P1312 **Pg 75**

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

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P1343 **Pg 75**

Development of Onboard Decision Supporting System for Ship Docking Operations

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P1399 **Pg 76**

Modeling of Offshore Crane and Marine Craft in Wave Motion

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P1480 **Pg 76**

A Human-Expertise Based Statistical Method for Analysis of Log Data from a Commuter Ferry

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P1551 **Pg 76**

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

Yuzhuo Ma[1], Tieshan Li[1,2], C. L. Philip Chen[3] and Liang'en Yuan[1]
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P1581 **Pg 76**

GPU-Based Optimisation of 3D Sensor Placement Considering Redundancy, Range and Field of View

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Dept. of Engineering Sciences, University of Agder, Grimstad, Norway.

Session [SS10]: Invited Session on Advanced techniques towards more electrified and intelligent mobility

P1530 **Pg 77**

Lithium-Ion Battery Parameter Identification and State of Charge Estimation based on Equivalent Circuit Model

Jiang Chang, Zhongbao Wei and Hongwen He
National Engineering Laboratory for Electric Vehicles, School of Mechanical Engineering, Beijing Institute of Technology, China.

P1555 **Pg 77**

Learning based Predictive Error Estimation and Compensator Design for Autonomous Vehicle Path Tracking

Chaoyang Jiang, Hanqing Tian, Jibin Hu, Jiankun Zhai, Chao Wei and Jun Ni
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P1557 **Pg 77**

Path Planning Method Design and Dynamic Model Simplification of Free-Flying Space Robot

Zhuoyi Xing, Yang Zhao and Shunjie Zhu
Institute of Spacecraft System Engineering in China Academy of Space Technology, Beijing, China.

P1564 **Pg 77**

Control Strategy of Lunar Lander-Relay Satellite Antenna Acquisition and Tracking for Chang'e-4 Lunar Exploration Mission

Yang Zhao, Ting Zhang, Xueying Wu and He Zhang
Institute of Spacecraft System Engineering in China Academy of Space Technology, Beijing, Chinal.

P1580 **Pg 78**

Multi-Layer Scheduling Optimization for Intelligent Mobility of Maritime Operation

Deqing Zhai, Xiuju Fu, Hai-Yan Xu, Xiao Feng Yin, Jayaraman Vasundhara and Wanbing Zhang
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P1587 **Pg 78**

Robust Energy Management for Uncertain Microgrid Using Modified Grey Wolf Optimizer

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Session [SS11]: Invited Session on Modelling and Control of Robots

P1375 **Pg 79**

Self-Calibration of Wearable Upper Limb Cabledriven Exoskeleton

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P1376 **Pg 79**

Experimental Implementation of Collective Motion based on Swarm Robotic Control

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School of Systems Science, Beijing Normal University, Beijing, China.

P1386 **Pg 79**

Comprehensive Characterization Method of Faulttolerant Kinematics Ability for Space Manipulator with Joint Locked Failure

Lanpu Li, Gang Chen, Yifan Wang and Yingzhuo Fu
School of Automation Beijing University of Posts and Telecommunications, Being, China.

P1411 **Pg 79**

Design of an Underactuated Body Fixture for a 7-DOF Cable-Driven Upper Limb Exoskeleton

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P1450 **Pg 80**

Variable Structure Compensation PID Control for Lower Extremity Exoskeleton

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P1607 **Pg 80**

Adaptive Locomotion of Lower Limb Exoskeleton Based on Oscillators and Frequency Adaptation

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

P1454 **Pg 80**

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

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P1461 **Pg 81**

Autocorrelation Convolution Networks Based on Deep Learning for Automatic Modulation Classification

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P1462 **Pg 81**

Deep Convolutional Neural Network with Wavelet Decomposition for Automatic Modulation Classification

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P1507 **Pg 81**

3D Semantic Segmentation Algorithm for Indoor Scenes based on Long-term Memory

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P1514 **Pg 81**

Design of Embedded Target Tracking System Based on MobileNet and KCF

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P1519 **Pg 82**

An Adaptive Gradient Method with Differentiation Element in Deep Neural Networks

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P1550 **Pg 82**

Dim Target Track-Before-Detect based on Particle Filtering

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Session [SS13]: Special Poster Session (I)

P1345 **Pg 82**

Edge Enhancement in Monocular Depth Prediction

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P1346 **Pg 83**

Dynamic Modeling and Control Methods of a Novel Electromagnetic-Driven Spherical Motion Generator

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P1359 **Pg 83**

Integration of Data Distribution Service into Partitioned Real-time Embedded Systems

Boyang Song, Xiaoguang Hu, Jin Xiao, Guofeng Zhang, Shuo Wang and Qing Zhou
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P1361 **Pg 83**

Mechanical Design and Optimization on Lower Extremity Rehabilitation Robot

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P1362 **Pg 83**

Virtual Test Modeling Method of Environment Control System in Aircraft

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P1387 **Pg 84**

The Technology of Bus Network Communication for Space Environment

Shuiqiang Pei[1], Dongying Ma[1], Xiaoguang Hu[2] Hui Wang[1] and Zhengtian Li[1]
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P1415 **Pg 84**

Research on PCIe Bus Communication Based on NeoKylin

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Session [SS14]: Special Poster Session (II)

P1436 **Pg 84**

Multi-Agent Cluster Systems Formation Control with Obstacle Avoidance

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P1457 **Pg 85**

A Robust SLAM towards Dynamic Scenes Involving Non-rigid Objects

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P1484 **Pg 85**

Research on Reconfigurable Technology and a Design of Application

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P1510 **Pg 85**

Simulation Technique of Optical Properties and its Applications for Complicated Appearance of Aeronautical Transparencies

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P1570 **Pg 85**

Visual Heart Rate Estimation from Facial Video Based on CNN

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P1585 **Pg 86**

Learning-based Remote Photoplethysmography for Physiological Signal Feedback Control in Fitness Training

Che-Ming Chang[1], Chun-Chen Hung[1], Changchen Zhao[2], Chun-Liang Lin[1] and Bo-Yuan Hsu[1]
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P1627 **Pg 86**

Dynamic Analysis and Controller Design for the Ballbot

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Session [SS15]: Special Poster Session (III)

P1347 **Pg 86**

Anthropomorphic Flexible Joint Design and Simulation

Zhuoyuan Chen[1], Shaoping Wang[1,2], Chao Zhang[1], Pengyu Zhang[1] and Zirui Liao[3]
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P1355 **Pg 87**

Vehicle Trajectory Recognition based on Video Object Detection

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P1366 **Pg 87**

Motion Characteristic and Analysis of Bionic Jellyfish with Fluid-Driven Soft Actuator

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P1367 **Pg 87**

Control for Networked Control Systems with Multiple Controllers

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P1373 **Pg 87**

Research on Modeling and Planning Method of Distribution Network with New Energy and Special Load

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P1397 **Pg 88**

Cloud-based Test Modeling and Automatic Generation of Test Cases

Jing Dai[1], Haoran Wang[2], Yue Ni[1], Haiyan Li[1] and Shuo Shi[1]
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P1412 **Pg 88**

Research on High Precision Positioning Servo Control of PMSM

Min Zhu[1], Zhilong Bai[1], Ao Liu[1], Chunling Yang[1] and Chaoyong Guo[2]
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Session [SS16]: Special Poster Session (IV)

P1424 **Pg 88**

Research on the Performance Evaluation of Lithiumion Battery Cascade Utilization Based on Impedance Spectrum

Chao Lyu[1], Gang Wei[1], Zhaoliang Wen[1], Hongying Zhang[1], Qi Wu[1] and Haitao Jing[2]
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P1425 **Pg 88**

Active Fault-Tolerant Control for Multi-agent System in Dynamic Tracking

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P1428 **Pg 89**

A Reduction Method for Thermal Modeling of Lithium-ion Battery based on Proper Orthogonal Decomposition

Chao Lyu[1], Yi Sheng[1], Shuang Zhang[1], Shihuai Zhu[1], Yankong Song[2] and Honghai Yu[3]
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P1429 **Pg 89**

An Electrochemical Thermal Coupling Model for High Crate Conditions in Lithium-ion Batteries

Chao Lyu[1], Yanben Zhao[1], Yitong Han[1], Qi Guo[1] and Xinfeng Zhao[2]
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P1430 **Pg 89**

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

Chao Lyu[1], Baozhao Ma[1], Shenglai Yan[1], Weining Li[1] and Haitao Jing[2]
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P1440 **Pg 90**

Experiment Design: Intelligent Traffic Management System

Haosong Yue, Huaiyi Mu, Haochen Liu and Yi Cai
School of Automation Science and Electrical Engineering, Beihang University, Beijing, China.

P1451 **Pg 90**

A Half-bridge Strategy Based Fault-tolerant Control for BLDCM under Open Circuit Fault

Shuai Wang, Xinhua Zhang, Guansong Xiong, Jun Wang, Zijun Zhang and Xingjian Wang
Servo Engineering Center, Beijing Institute of Automatic Control, Equipment, Beijing, China.

Session [SS17]: Special Poster Session (V)

P1466 **Pg 90**

RUL Prediction of Lithium Batteries based on DLUKF Algorithm

Ting Tang, Hui-Mei Yuan and Jun Zhu
Information Engineering College, Capital Normal University, Beijing, China.

P1486 **Pg 90**

Mining Diagnostic Knowledge from Spacecraft Data Based on Spark Cluster

Haoran Wang[1], Jinsong Yu[1], Diyin Tang[1], Danyang Han[1], Limei Tian[2] and Jing Dai[3]
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P1493 **Pg 91**

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

Yao Wu[1], Jinsong Yu[1], Diyin Tang[1], Limei Tian[2], Zhanbao Gao[1] and Jing Dai[3]
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P1503 **Pg 91**

6LoWPAN Protocol Based Infrared Sensor Network Human Target Locating System

Bo Yang, Fuhuang Liu, Lulu Yuan and Yukexin Zhang
School of Automation Science and Electrical Engineering, Beihang University, Beijing, China.

P1528 **Pg 91**

Research on Target 3D Reconstruction and Measurement Technology based on Binocular Vision and Lidar

Yue Ni, Jing Dai, Yaolei Zhang, Yidong Chen and Xiaoyu Ma[e]
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P1558 **Pg 91**

Research on a Servo Control System for Flow Regulation

Wang Aping, Xu Haobang, Li Huaibing and Liu peng
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P1616 **Pg 92**

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

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Session [SS18]: Invited Session on Advanced control technologies for robotic system and its applications

P1037 **Pg 92**

Disturbance Observer Based Robust Adaptive Control of Maglev System

Jiaqi Liu, Xiangbin Liu and Kangjun Wang
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P1123 **Pg 92**

Stiffness Estimation and Intention Detection for Human-Robot Collaboration

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P1137 **Pg 93**

Online Parameter Estimation For Uncertain Robot Manipulators With Fixed-time Convergence

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P1212 **Pg 93**

Trajectory Tracking Control of Robotic Manipulators by Multi-layer Neural Networks

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P1225 **Pg 93**

Global Fast Terminal Sliding Mode Control for a Quadrotor UAV

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Session	[SS19]: Invited Session on System Design and Test

P1363 **Pg 93**

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

Zhiyong Tang, Jianbing Yang, Zhongcai Pei and Xiao Song
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P1371 **Pg 94**

Design and Research of an Automatic Charging System for Electric Vehicles

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

P1398 **Pg 94**

Research on Payload Distribution of UAV Formation with Constraints

Jin Xiao[1], Zhiwei Zhu[1], Xiaoguang Hu[1], Guofeng Zhang[1] and Lei Liu[2]
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P1419 **Pg 94**

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

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P1489 **Pg 94**

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

Liwen Zhang[1], Jinsong Yu[1], Diyin Tang[1], Danyang Han[1], Limei Tian[2] and Jing Dai[3]
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Session	[SS20]: Invited Session on Advanced Modeling, Analysis and Control Techniques and Emerging Applications of Modular Multilevel Converters

P1124 **Pg 95**

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

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P1257 **Pg 95**

Method of Field Limiting Rings Spacing Parameter for SiC JBS Based on Multiple Linear Regression and Polynomial Fitting

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P1290 **Pg 96**

Minimal Capacitor Voltage Ripple Control for the Modular Multilevel Converter Based Wind Energy Conversion System

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P1591 **Pg 96**

Multi-Stage Planning of Active Distribution Network Considering Correlation and Time Sequential Features

Yuqi Han[1], Jun Wei[1], Shengyong Ye[1], Yishuang Hou[2], Xuna Liu[1], Wentao Zhang[1,e], Chuan Long[1,f] and Jieying Liu[1,g]
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P1280 **Pg 96**

FPGA-Based High-Frequency Pulse Power Supply for Micro Electroplating

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Session [SS21]: Invited Session on System Simulation and Analysis

P1385 **Pg 96**

Formation Transforming Policy for Multi-agent System in Planetary Exploration

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P1416 **Pg 97**

Modeling of Switched Reluctance Generator Based on Modelica

Zhao Xu[1], Xiaoguang Hu[1], Jin Xiao[1], Guofeng Zhang[1] and Lei Liu[2]
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P1478 **Pg 97**

Data Analysis of Bitcoin Blockchain Network Nodes

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P1522 **Pg 97**

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

Li Wang, Min Zhu and Chunling Yang
School of Electrical Engineering and Automation, Harbin Institute of Technology, Harbin, China.

P1266 **Pg 97**

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

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P1572 **Pg 98**

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

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P1576 **Pg 98**

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

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Session [SS22]: Invited Session on Design for Electrical Components and Systems

P1351 **Pg 98**

Design of EtherCAT Slave System Based on Zynq-7020 Chip

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P1381 **Pg 98**

The Design of University Staff Data Management System Based on MBSE

Dawen Ding and Zhiqiang Zhao
Information Center Capital Medical University Beijing, China.

P1502 **Pg 99**

High-resolution Thermopile Array Sensor-based System for Human Detection and Tracking in Indoor Environment

Nanhao Gu, Bo Yang and Tianfu Li
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P1536 **Pg 99**

Design and Simulation of Large Flowrate Fuel Metering Valve of Aero engine Based on AMESim

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P1396 **Pg 99**

Distributed Formation Control of Autonomous Underwater Vehicles Without Velocity Measurement

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

P1420 **Pg 100**

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

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P1441 **Pg 100**

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

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P1609 **Pg 100**

A Hybrid AC/DC Microgrid Energy Management Strategy Based on Neural Network

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P1210 **Pg 100**

Progress of DC Quench Protection Switch for Superconducting Fusion Reactors

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P1025 **Pg 101**

A Reactive Component Elimination Method for Voltage and Current Stresses Analyses

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Abstracts

Sessions will be online for viewing from 18 - 24 October 2020

Session [LS01] LS01: Best Paper Award Selection

P1310

MegaSense: Cyber-Physical System for Real-time Urban Air Quality Monitoring

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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, privacyaware 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 smart phone 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.

P1498

Model Predictive Control and Disturbance Compensation for Engine Test Beds

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Engine test beds play a big role in developing and validating all sorts of drive systems. Utilizing them for Hardware-in-the-Loop (HIL) tests enables parallel development of components and therefore decreases the overall design process time. The controllers for such tests need to be highly accurate in order to justify emulation of real-world operations. When combustion engines are considered, a common problem with engine test beds are the periodic oscillations that are induced by the combustion strokes. Ordinary controllers try to compensate these oscillations and thereby, introduce additional, undesired loads to the device under test (DUT). In this paper, a way to overcome this problem is presented. A model predictive control scheme uses information about future disturbances to regulate the engine speed. The unknown combustion torque is estimated by a parametric Kalman filter. Experimental results on a laboratory setup prove the practicability of the proposed methods.

Keywords: Industrial drives, model predictive control, parametric Kalman filtering, test bed control.

P1516

A Novel High Frequency Isolated Three-Level Inverter and Its Topological Derivation Method

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High frequency isolated multi-level inverters (HFI-MLI) feature a variety of merits, such as low voltage stress of power switches, low THD of unfiltered voltage, small size of output filter. However, only a few researches on HFI-MLI without intermediate DC link have been carried out. Thus, topological derivation method suitable for HFI-MLI and novel HFI-MLI topologies need much more research and discussion. A topological derivation method, named as Loop Construction Method(LCM) is proposed in this paper.

Active and/or passive components are used to construct independent and controllable current loops between different potential points and high frequency transformer windings, so as to obtain novel HFI-MLI topologies. In addition, several novel topologies, constructed by LCM, are discussed. Furthermore, taking push-pull HFI-3LI as an example, the working operations and control strategy 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.

P1517

Adaptive Weighted Robust Principal Component Analysis

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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. We first estimate the rank of the clean data contained in the observation data by Gerschgorin disks method. Then the weights are adaptively updated by considering some singular values based on the estimated rank, thus both the number and size of the singular values are considered to recover the lowrank matrix with correct information. Experimental results show that the proposed adaptive weighted RPCA algorithm can achieve better performance under various conditions compared to the existing algorithms.

Keywords:
Robust principal component analysis, Nuclear norm minimization, Gerschgorin disks estimation.

P1586

A Temporal Forecasting Driven Approach Using Facebook's Prophet Method for Anomaly Detection in Sewer Air Temperature Sensor System

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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.

P1602

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] TT01: 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 information and structure 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;

Nerve Center from Mezzanine system of Oblong Industries.

Keywords: Industry 4.0, Control room, Facial recognition, Hand gesture recognition, Display system.

P1040

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.

P1055

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.

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.

P1203

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-tofine, fast device detection and recognition method is proposed. The coarse detection is based on objectness, using 8 × 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.

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.

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.

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.

P1023

Automatic Generation Method of Ancient Poetry Based on LSTM

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This paper mainly focuses on the literary genre of ancient poetry with a certain rhythm and cadence, and proposes a novel automatic generation model of ancient poetry. The model uses about 300,000 Tang poems and Song poems as training data, uses One-hot encoding to process data, and uses long short-term memory networks (LSTMs) to learn the semantics of ancient poetry texts and conduct research across a single RNN structure. According to the user's requirements, the model can automatically calculate the most relevant coherent words in the context of the selected context, and generate common ancient poetry and specified words. The method of BLEU automatic evaluation and manual evaluation finally demonstrates the effectiveness of the experiment.

Keywords: Neural network, Long short-term memory network, Automatic generation of ancient poetry.

Session [TT03] TT03: Industrial Information & Computational Intelligence (III)

P1082

Fault Diagnosis of Subway Plug Door Based on KPCA and CS-LSSVM

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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 technologies 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 used in subway 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.

P1612

Adaptive Multi-Layer Structure for Anomaly Detection in Hyperspectral Images

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Most traditional hyperspectral image (HSI) anomaly detection (AD) algorithms often consider the spectral difference between the anomaly and its background pixels, ignoring the local spatial structure information. An Adaptive Multilayer Structure for hyperspectral image anomaly detection is proposed to handle this problem. This new algorithm not only calculates the spectral dimension difference between the pixel to be measured and the pixel in the background window, but also measures the spatial structure difference

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.

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 singleobjective 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.

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.

P1143

Multicriteria Group Decision Making Approach for Evaluating the Performance of FinTech Projects

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Financial technologies (FinTech) are gaining popularity amongst organizations due to its ability in improving their competitiveness. As a result, organizations are seeking ways in the development of FinTech projects. The performance evaluation of the most suitable FinTech project, however, is complex and challenging due to the involvement of multiple decision makers, the multi-dimensional nature of the evaluation process and the presence of vagueness and imprecision inherent in the human decision making process. To deal with this problem, this paper presents a multicriteria group decision making approach for evaluating the performance of FinTech projects. Intuitionistic fuzzy numbers are used for effectively modelling the vagueness and imprecision of the decision making process. A multicriteria group decision making approach is developed for calculating an overall performance index for every FinTech project alternative across all criteria. A FinTech project performance evaluation problem is presented to demonstrate the effectiveness of the approach.

Keywords: Financial technology, Performance, Multicriteria, Group decision making, Projects.

Session [TT04] TT04: Industrial Informatics & Computational Intelligence (IV)

P1610

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 fulfil 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/ negotiation (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.

P1166

Fault-Tolerant Application Mapping on to ZMesh Topology based Network-on-Chip Design

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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. Experimentations 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.

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

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 diagnose. 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.

P1497

A Review on Data Analysis of Bitcoin Transaction Entity

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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 Bitcoin, 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.

P1501

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 <001> 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.

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

P1520

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 eventtriggered 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.

P1221

Health Status Evaluation of Intelligent Power Distribution Room based on AHP- Entropy method

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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.

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.

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.

P1525

Research on Task Decompsition and Optimization Methods of Cyber Physical Systems

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The key to achieve a certain goal for Cyber Physical Systems is coordination of system tasks. By analyzing the characteristics of CPSs, an approach for task decomposition was proposed. This approach uses design structure matrix (DSM) to describe the relationship of the tasks, decomposes tasks by decoupling and recombination according to the degree of coupling between atomic tasks. Furthermore, the task process model based on Petri net is constructed for the decomposed sub-tasks, and the relationship of sub-tasks is graphically shown, which provides a theoretical basis for the task execution and scheduling and dynamic reorganization of CPSs resources.

Keywords: CPSs, Task decomposition, DSM, Decoupling, Process model.

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] TT06: Cyber-physical Systems (II)

P1631

A Data Mining Framework to Predict Cyber Attack for Cyber Security

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Cyber-attacks are exponentially increasing daily with the advancements of technology. Therefore, the detection and prediction of cyber-attacks are very important for every organization that is dealing with sensitive data for business purposes. In this paper, we present a framework on cyber security using a data mining technique to predict cyber-attacks that can be helpful to take proper interventions to reduce the cyber-attacks. The two main components of the framework are the detection and prediction of cyber-attacks. The framework first extracts the patterns related to cyber-attacks from historical data using a J48 decision tree algorithm and then builds a prediction model to predict the future cyber-attacks. We then apply the framework on publicly available cyber security datasets provided by the Canadian Institute of Cybersecurity. In the datasets, several kinds of cyber-attacks are presented including DDoS, Port Scan, Bot, Brute force, SQL Injection, and Heartbleed. The proposed framework correctly detects the cyber-attacks and provides the patterns related to cyber-attacks. The overall accuracy of the proposed prediction model to detect cyber-attacks is around 99%. The extracted patterns of the prediction model on historical data can be applied to predict any future cyber-attacks. The experimental results of the prediction model indicate the superiority of the model to detect any future cyber-attacks.

Keywords: Cyber attack, Cyber security, Cyber attack prediction, Data mining, Decision tree, Accuracy.

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 has demonstrated the cryptographic excel-

lency of the proposed encryption algorithm.

Keywords: Fractional-order, Hyperchaos, Chen system, Image encrytion, Information security.

P1279

Research on Task-Oriented Dynamic Reconstruction Method of UAV Swarm Evolutionary Game

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The reconnaissance or electronic warfare payload UAV swarm with 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 / hit 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 particulate 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 lowcost 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.

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. We chose a case study of shifting from conventional screen-printing to more environmentally sustainable digital textile printing. We suggest that this shift can be accelerated if the brand owners join their forces together to shift from conventional printing to digital printing technology in the apparel industry.

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

Session [TT07] TT07: Control and Systems (I)

P1202

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-neuronbased 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.

P1619

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 highprecision 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 in theoretically. Result of simulation shows that the robust adaptive controller performs better than the PD and feedforward controller. The characteristics of dynamic and accuracy are both improved.

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

P1001

DFIG Pitch Angle Control with PID-type Fuzzy Logic Controller in a Microgrid

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In the present-day power system with renewable sources, Doubly Fed Induction Generator (DFIG) is broadly 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 proposed and incorporated in the pitch angle control (PAC) to enhance rotor speed and active power regulation of DFIG. Matlab/Simulink software based realtime 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.

P1209

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 errors. 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.

P1116

An Efficient Motion Trajectory Planning Method in CNC System

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Lines and circular arcs are commonly used in CNC systems, the numerical controller always treats them separately, in two different routines. In this paper, a circle discrete method

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 readjust 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 (CMPFC) system using a saliency ratio of the SynRM to generate a fixed current angle command is introduced. Since the saliency ratio needs offline prepreparation 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 recalculates 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.

P1118

INTSMC-Based Fault Tolerant Control Approach for a 2-DOF Robotic System

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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 design includes a comprehensive actuator fault model that encompasses different scenarios of bias and loss of effectiveness faults. The stability of the proposed FTC module is verified based on the Lyapunov stability criteria. The overall scheme was implemented to a second-order robotic system subject to different faulty scenarios. 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.

P1220

A New Approach to Development and Validation of Artificial Intelligence Systems for Drilling

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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 highfidelity 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.

P1313

Optimal Control Design for a Group of Mobile Robots with Uncertainties

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The paper considers the problem of optimal control design in the presence of uncertainties. Uncertainties of various nature are almost always appear in real objects. They can be caused by inaccuracy of the model, noise, uncertainty of the initial conditions and so on. It is proposed to use a new two-stage approach of synthesized optimal control, which at the first stage mathematically solves the problem of synthesis of the stabilization system and then the optimal trajectory of motion for the updated stabilized object is searched for. The implementation of such optimal control over a stabilized object makes it possible to level out model inaccuracies or other uncertainties much better than directly solving the optimal control problem, which is shown in a comparative example of solving the optimal control problem for a group of four mobile robots moving in a complex environment with phase constraints.

Keywords: Control synthesis, Stabilization, Uncertainty, Group of robots.

Session [TT09] TT09: Control and Systems (III)

P1044

Fault Identification for Systems Described by Nonlinear Models Using Sliding Mode Observers

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The paper studies the fault identification problem for

nonlinear control systems under the unmatched 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.

P1145

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.

P1487

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 nonlinearity 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: Bilateral network delay, Sliding mode control, Lyapunov stability.

P1016

Stabilization of Nonlinear Networked Switched Control Systems with Delays and Packet Losses

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This paper studies the stabilization problem for nonlinear NCSs(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.

P1435

Unbalanced Voltage Control of Bipolar DC Microgrid Based on Distributed Cooperative Control

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The change of positive and negative DC load of bipolar DC microgrid will cause the voltage of dc-bus to deviate from the rated value, causing the positive and negative voltage to be unbalanced, and will increase the network loss. In order to coordinate the participation of different distributed power sources in the unbalanced voltage control of DC microgrid, this paper adopts the distributed cooperative control combined with primary control and secondary control. The droop control is taken as the primary control

link of the bipolar DC microgrid, and an unbalanced voltage observer and an unbalance factor controller are established based on the consensus algorithm as a secondary control link to integrate the average dc-bus voltage and the voltage unbalance factor control. In this way, the voltage unbalances between poles and the average dc-bus voltage will reach consensus and maintain at the rated value. The simulation platform of bipolar DC microgrid is built in MATLAB/Simulink, and the effectiveness of the control strategy is verified.

Keywords: Bipolar, DC microgrid, Unbalanced voltage, Distributed cooperative control.

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 DTFC-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: Ventilation duct system, Air balancing, Distributed finite-time control, Consensus algorithm, Model-free.

P1179

Multi-Tasking Syetem Design for Multi-Axis Synchronous Control of Robot Based on RTOS

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With the complexity of industrial robot mechanisms, from multi-axis single-arm robots to multi-axis dual-arm robots to multi-robot collaborations, the requirements for real-time communication and synchronous control of robots have become higher and higher. In order to solve the problem of real-time communication and synchronization of control of the complex mechanism of the robot, a real-time robot control system with a multi-task structure based on an open source RTOS is designed. First, the development direction of contemporary robot controllers and some mainstream robot controllers are introduced. Then, the overall architecture of the real-time robot control system based on EtherCAT is given in the real-time requirements of the control system. The control system is based on the open-source SylixOS embedded RTOS. It follows a modular concept and uses the control layer as the core to form a real-time multi-tasking structure. With the help of the EtherCAT open-source protocol stack code, the controller and the servo drive system can realize real-time data interaction. Then, test whether the RTOS's real-time performance meets the controller's requirements, and analyze the EtherCAT synchronization mechanism. Finally, a real-time multi-task control system experiment on a dual-arm robot is built.

Keywords: RTOS, Real-time Multi-tasking, EtherCAT, Distributed clock synchronization.

P1301

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 proportional 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.

P1197

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.

P1468

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.

P1540

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

accuracy theoretically. Aiming this disadvantage, the paper establishes a more accurate IR decoy simulation model, by adding chemical combustion phase based on the enhanced DPM IR decoy model. Experimental results show that the simulation accuracy of new model's graphics characteristics and radiation characteristics is obviously improved compared to the traditional model, by adding chemical combustion phase.

Keywords: Modeling of infrared decoy, DPM model, CFD, Chemical combustion.

Session [TT11] TT11: Energy and Environment (I)

P1172

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 (HESS) 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.

P1095

Energy Management Strategy Based on a New Adaptive Filtering Algorithm for Battery-Ultracapacitor Electric Vehicles

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This paper presents an energy management algorithm based on a new adaptive filtering method for a multi-sources battery-ultracapacitor electric vehicle. Compared to literature where most of the filtering techniques are developed based on empirical knowledge of the system, the proposed adaptation method is performed online to optimize a cost function that considers the state of charge of the ultracapacitor. The developed approach allows a better power sharing between both electric sources while respecting their constraints and physical limitations. Simulations on Matlab/Simulink validate the performances of the proposed method.

Keywords: Electric vehicle, Energy management strategy, Ultracapacitor, Battery, Adaptive filtering.

P1284

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 highlevel optimizes energy flow of substation, and the low-level controls power redistribution of HESS. 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 took 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.

P1285

An Advanced Traction Power Supply System in Electrified Railway

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Recent years, with the rapid development of highspeed 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: Energy storage system, Coordinated control strategy, Power flower controller.

P1606

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 generator(DFIG) is proposed. According to the frequency variation of inertial 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: Doubly-fed wind turbines, Exponential function, Virtual inertia, Adaptive control.

P1233

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 algorith.

Session [TT12] TT12: Energy and Environment (II)

P1524

Comparison of ESS Configurations and IC Control Technologies in Islanded 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 (IHMG), keeping the power balance and voltage/ frequency regulation is chal-

lenging task mainly because the absence of a dominating source and the low physical inertia of the limited DG units. The use of the energy storage systems (ESS) and interlinking converter (IC) technologies for meeting the above challenges is a widely accepted idea. This paper examines connection topologies of the ESS and the corresponding control approaches of IC and defines and explains five typical operation modes for IHMG. The unified power equations are proposed. The different operation modes can be represented through different assignment of input parameters of the equations. The operating characteristics of the IHMG are obtained by solving the equations. Finally, the accuracy and effectiveness of the proposed scheme are verified against the time domain simulation result. The quasi-steady-state behaviors of multi-DC subgrids IHMG in different modes are investigated. The results show that the location of the ESS device and the control scheme adopted by IC is closely related to the operating characteristics of the IHMG.

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

P1590

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 hybrdi 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 co-phase traction substation (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.

P1155

Energy Storage System as Auxiliaries of Internal Combustion Engines in Hybrid Electric Ships

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This paper presents a design concept to overview the feasibility of utilizing modern energy storage systems as substitution of conventional machinery auxiliaries, which are necessarily installed to support internal combustion engines' operation. For example, the common compressed air system required for engine starting and emergency stopping occupies substantial space in the machinery space of the ship. Owing to increased capacity and reduced price of batteries nowadays, electric motors and solenoid valves can supersede the compressed air system, and we can save space and reduce capital expenditures as well. The cranking torque for engine starting, motor driving current, the optimal control system is simulated to validate the performance of the engine starting system, in line with the simulation of charging and discharging of an energy storage system.*Keywords:* Engine starting system, Battery management system, Transportation electrification, DC motor control, DCDC converter, Energy storage system, Hybrid ships.

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 for islanded microgrids. However, a layering of primary, secondary, and tertiary control may cause incoordination 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.

P1512

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 be become an important factor to consider when considering LCOE of WT.

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

P1171

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

Session [TT13] TT13: Energy and Environment (III)

P1515

Honeycomb Active Distribution Network: A Novel Structure of Distribution Network and Its Stochastic Optimization

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It is increasingly harder for the distribution network with conventional structure to cope with the significant growth and penetration of large quantities of distributed renewable energy and the application of various power electronic devices, meanwhile the uncertainties of intermittent energy and consumer loads also bring challenges to distribution system operators (DSOs). This paper proposes a novel honeycomb structure of distribution network with smart power/information exchange station (SPIES) to overcome the shortcomings of conventional distribution network. The characteristics and promising advantages of the proposed honeycomb active distribution network (HADN) are firstly presented. Then a two-stage energy dispatching model of HADN is established, consisted of the day-ahead dispatch and real-time operation. The former is based on forecasted data and the latter includes the system uncertainties, which bring the finical risks. Inspired by the risk management in the financial sector, the risk of uncertainties in the energy dispatch of HADN is modeled using the conditional value-at-risk (CVaR). Therefore, a two-stage stochastic energy dispatching model with CVaR for HADN is studied in this papar, and its feasibility is tested and verified through the numerical simulation, in which Monte Carlo method and cluster analysis are adopted to simulate uncertainties. The results in this paper reveal the feasibility of the energy dispatching method for HADN considering risk and the important role of SPIES, which can provide the guidelines for implementation and economic dispatch of HADN.

Keywords: Distributed renewable energy, Microgrid cluster, Smart grid, Stochastic optimization, CVaR, Risk management, Monte carlo method, *k*-means clustering.

P1293

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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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 Buttler-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.

Keywords: Wind turbine, Yaw system, Stochastic model predictive control, Multi-scenario optimization, Synchronous backward substitution method.

P1108

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.

Session [TT14] TT14: Energy and Environment (IV)

P1099

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.

P1109

An Ultra-Short-Term Prediction Method for Wind Speed Series based on Gaussian Process Median Regression

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With the development of Wind power grid connection technology, the ultra-short-term wind speed prediction technology plays an important role in power system operation and energy scheduling. This paper proposes a median regression prediction model based on Gaussian process(GPMR). This model can accurately analyze and predict the time series of ultra-short-term wind speed from several minutes to an hour. Based on the assumption of prior distribution by Gaussian process, this method solves the problem of nonlinear processing in the conventional time series method. It also combines with the selection of median, overcoming the shortcoming that the previous mean point prediction is easily affected by large error deviation, making the prediction result more representative. In the part of example analysis, two machine learning prediction methods commonly used in recent years are compared, and the simulation results show that the method proposed in this paper is more accurate in the ultra-short-term prediction of wind speed.

Keywords: Gaussian Process (GP), Median regression, Wind speed ultra-short-term prediction.

P1246

Variable Time Constant Smoothing Strategy Based on Wind Power Flattening Index

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The selection of time constant is the key to suppress the fluctuation of wind power output by using the firstorder filter. This paper analyzes the relationship between the filtering time constant and the fluctuation smoothing quan-

tity in different time scales according to the wind power fluctuation smoothing index. And proposes a strategy of putting two timeconstant filters in series to suppress the fluctuation of wind power on two time scales. Setting the wind power fluctuation threshold of energy storage switching and adjusting the time constant near the threshold smoothly to reduce the impact of energy storage switching on the wind/storage system output fluctuation. Finally, the wind power data measured in a wind field is taken as an example to conduct simulation analysis through MATLAB/Simulink, which shows that the proposed strategy can meet the requirements of wind power index and reduce the energy storage grid operation time and charge and discharge times.

Keywords: Wind power generation, Power fluctuating, Low pass filter, Varying time constant, State of charge.

P1458

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 by using the test data at different discharge rates. Experiments with measured data indicate that compared with the traditional BP neural network, the estimation model proposed in this paper has higher accuracy of SOC estimation and smaller relative error.

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

P1463

Lithium Battery SOC Estimation Based on Improved Unscented Kalman Filter

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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 based on Singular Value Decomposition (SVD) is used, this algorithm uses traceless transformation for accuracy improving, while using Singular Value Decomposition for calculation stability. 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.

P1317

Optimal Rural Integrated Energy System Configuration against the Background of the Rural Energy Transformation Strategy

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This paper presents a set of optimal configuration methods for rural IES. First, the economic model of the rural IES model is constructed and a five-level energy hub model is established to deal with the problem of multi-energy coupling. Then, a two-layer optimization structure considering optimal configuration and operations is designed used Particle Swarm Optimization (PSO) and mixed integer linear programming as the solving algorithm. Finally, taking Donghan Village in Shaanxi Province, China as an example, the validity of the proposed method is verified.

Keywords: Rural IES, Optimal configuration, Multi-energy coupling, Energy hub, PSO.

Session [TT15] TT15: Robotics (I)

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 (GDGIF) 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 unscented 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 0.10m 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 new 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.

P1295

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 acutators, Linear actuators, Actuation system design, Component selection, Electro-mechanical cylinders, Electro-hydraulic cylinders, Valve-controlled cylinders, Load-carrying applications.

P1413

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.

P1323

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.

Session [TT16] TT16: Robotics (II)

P1102

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.

P1421

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 maybe 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 compare to conventional control methods.

Keywords: Exoskeleton Robot, Adaptive, Backstepping.

P1187

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 positions, 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 processes 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.

P1267

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 Cortexm4 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.

P1567

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 much 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 promises 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.

P1298

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 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.

Session [TT17] TT17: Robotics (III)

P1178

Trajectory Sampling and Fitting Restoration Based on Machine Vision for Robot Fast Teaching

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Industrial robot teaching movement methods can be roughly divided into two types: direct teaching and offline teaching. Because the offline teaching method requires modeling of the robot and its surroundings, the technical requirements of the operator are high and the process is time-consuming and energy-consuming, the direct teaching method is commonly used. However, when the trajectory of the robot movement is complicated, a large number of points need to be taught to ensure the accuracy of the movement. In order to improve the teaching efficiency, a rapid teaching method for industrial robots based on machine vision technology is proposed. This method requires the robot to move on a fixed plane and achieves rapid teaching by sampling and fitting the robot's end trajectory. Firstly, a robot visual teaching system composed of a robot movement control subsystem and a visual image acquisition and processing subsystem is set up, which solved the communication problem between B & R real-time operating system and Windows operating system. It realizes direct observation of movement trajectory by method of "eye-in-hand". Then, using the data points obtained by manual sampling, a cubic B-spline curve fitting algorithm is used to fit and restore a continuous and smooth trajectory curve. Using the camera's internal and external parameters and the hand-eye calibration results, the target set point sequence to which the robot end should move can be inversely calculated. Finally, the experiment discusses the influence of different sampling methods on the trajectory restoration result and obtains the optimal sampling method to improve the accuracy of trajectory restoration. Although this method cannot be applied to scenarios with strict location accuracy requirements, it can

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 analytical 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 microdimers 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.

Session [TT18] TT18: Power Electronics (I)

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

can be used to guide temperature rise tests of the dry-type reactor in future projects.The research can provide reference for type design and selection of reactors under AC-DC combined large current in future projects.

Keywords: VSC-HVDC, Valve bridge arm reactor, Temperature rise, AC current combining with and DC current.

P1339

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 capacity 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 shortcircuit 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.

P1408

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 newgeneration 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.

P1500

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.

Keywords: 250 kW high-frequency transformer, Multi-winding output series structure, Secondary winding bobbin.

P1597

An Optimized Fault Feature Extraction Method for PV Grid-Connected T-Type Three Level Inver

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Referencing to the single switch open circuit fault in T-type three level grid-connected inverter, a new fault feature extraction method based on optimal wavelet packet energy feature extraction and FFT technique is proposed in this paper. In this method, the wavelet packet is used to decompose the three-phase fault current in multiple layers, and then the proportion of the lowfrequency component energy to the total energy is extracted as the basic fault characteristic value. Optimizing the basic fault characteristic value based on the three-phase current average change trend. Then execute FFT technique on the current of the fault phase, and extract the amplitude of the fundamental wave as an additional fault characteristic value. The fault feature extraction method only needs to analyze the three-phase current, and the algorithm is simple and easy to realize. It can be applied to the fault feature extraction of switch open-circuit fault in most Ttype three level grid-connected inverter systems. The simulation results show that the fault feature extraction method combined with neural network can effectively realize the fault diagnosis of single switch open circuit of T-type three level grid-connected inverter.

Keywords: T-type inverter, Fault feature extraction, Wavelet packet, FFT technique.

P1107

Enhancing Short Circuit Ruggedness of 1.7 kV IGBTs using a Gate-Source-Shorted Depletion-Mode MOSFET in Series with the Emitter

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Commercial IGBTs optimized with low on-state voltage drop ($V_{CE,SAT}$) have poor short circuit ruggedness (t_{SC}). This paper demonstrates a new concept to enhance t_{SC} for commercially available 1.7 kV IGBTs designed with low $V_{CE,SAT}$ using a gate-source-shorted (GSS) Si depletion-mode (DM) MOSFET in series. A five-fold improvement in (t_{SC}) to over 25 μs was achieved at a DC bus voltage of 1100 V with only 15% increase in ($V_{CE,SAT}$) and no change in total switching loss. The new concept also provides a sense voltage to monitor collector current during normal circuit operation and to detect SC events.

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

Session [TT19] TT19: Power Electronics (II)

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).

P1306

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 are 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, Measurement, Internal processes, Rotating rectifiers, Thyristor rectifers, IGBT converter, Rotating capacitor, Rotating chopper, Rotor field excitation, Brushless electrical machines.

P1402

Research on Power Electronic Transformers Based on Virtual Synchronous Machine Control

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In order to achieve the goal of friendly interface between microgrid and powe system main network, this paper studied a cascaded H-type Power Electronic Transformers (PET) scheme which use virtual synchronous machine control. After analyzing the main circuit topology and working principle of PET, this paper explained the implementation process of the control strategy based on the Synchronverter virtual synchronous machine, and introduced the cascaded H-bridge voltage equalization control to further achieve the effect of stable output voltage. Finally, the paper built a system simulation model based on Matlab/Simulink. The simulation results show that the PET scheme studied in this paper can not only adjust autonomously in response to changes of Microgrid voltage and frequency, but also can provide support for the voltage and frequency stability of the main grid of the power system.

Keywords: Microgrid, Power electronics transformer, Virtual synchronous machine, Equal pressure control.

P1453

DC Solid State Circuit Breaker Based On GaN

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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. The details on 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, currentlimiting, Fast and asccurate break.

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 peakshaving 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 Islanded Microgrids Using Adaptive Virtual Capacitance

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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.

Session [TT20] TT20: Power Electronics (III)

P1204

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. Considering 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.

P1296

Power-Based Phase-Locked Loops for Single-Phase Applications—A Survey

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In the distributed power generation systems (DPGSs), ensuring the synchronization with the utility grid is crucial for the stable operation of grid-connected systems. Among various synchronization techniques, the power-based phase-locked loop (pPLL) has gained much attention due to its relatively simple implementation of the phase detector, extraordinary harmonic filtering capacity and robustness even under large grid variations. However, this kind of PLL suffers from an inherent problem called "double-frequency oscillation". The aim of the study is to review and compare the existing pPLLs. According to the difference in coping with this drawback, pPLL can be divided into two categories: cancellation with inloop filter (CIF) and cancellation with opposite component (COC). Working principles and main characteristics of different pPLLs are then discussed. At last, some simulations and discussions are provided.

Keywords: Synchronization, Grid-connected systems, Singlephase, Power-based phase-locked loop.

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 established to divide buses into different groups according to the similarity degree of their load curve. When the load uncertainty model was established, it would be inserted into the proposed Monte Carlo - continuation power flow

(MCCPF) algorithm. Two risks indexed focusing respectively on bus and entire system were proposed and would be calculated based on MCCPF performance results, an integrated risk assessment framework was then founded. Taking the 110kV power grid in Taiyuan City as an example, the static voltage stability risk assessment indicators of the EV access area power grid are analyzed, including the average network average load risk index and the node low-voltage load risk index, respectively describing the static voltage stability risks of the system and nodes, and the validity and effectiveness of proposed method is verified.

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

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 voltage 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 R_d damping circuit and R_d-C_d 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: Arc furnace, Voltage distortion, Photovoltaic system, PLL, PSCAD/EMTDC.

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, Harmonic detection, Id-Iq strategy.

Session [TT21] TT21: Power Electronics (IV)

P1433

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 antiinterference 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 power response speed is faster, the overshoot is smaller, and the steady state can be recovered faster.

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

P1322

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 gird 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. A 400W prototype has been built to verify the effectiveness and advantages of studied method.

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

P1265

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.

P1325

Microcontroller-Based Implementation of a Direct AC-AC SPWM Power Converter

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A novel low frequency AC-AC SPWM modulated frequency converter is implemented based on Microcontroller chip. The control function performed by the Microcontroller chip AT89C51 is twofold: firstly, to achieve frequency conversion by changing number N of half wave, between two natural commutation points. Secondly, to obtain voltage regulation by changing the duty-cycle of PWM pulse (high frequency) in the half wave of grid power passing through. As a result, the

Microcontroller-based direct AC-AC converter can achieve voltage regulation and frequency conversion at the same time, which is suitable for motor of flexible low-frequency speed regulation. The Microcontroller-based control algorithm and the implementation are presented in detail and the design is verified by both simulation and experimental testing results.

Keywords: AC-AC frequency conversion, Pulse-skipping, Microcontroller, V/F control.

P1434

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).

P1456

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.

Session [TT22] TT22: Power Electronics (V)

P1471

ANPC Three-level Model Predictive Control Strategy Without Weight Factor

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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 threelevel 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.

P1476

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

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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 neutral point voltage based on the redundant switch state selection is studied; Finally, the feasibility of the topology and the effectiveness of the control strategy are verified by simulation.

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

P1541

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 feasibilities of the proposed converter and power line communication method.

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

P1563

Performance Evaluation of LC-L Resonant Converter with Integrated Magnetics

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In this paper, the LC-L resonant converter, whose resonant inductor is placed at the secondary side of the transformer, 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 transformer 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 430V/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: Resonant converter, LLC, LC-L, Equivalence relation, Magnetic integration.

P1009

A New Wideband Modeling Method of Converter Transformer

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In order to effectively calculate the electromagnetic transient characteristics of converter transformer to avoid resonance and overvoltage faults, 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 in high frequency of transformers are calculated. The leakage inductance parameters of transformers are obtained by calculating inductance matrix through finite element method. 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 capacitors 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.

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 decisionmaking. 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.

Session [TT23] TT23: Power Electronics (VI)

P1249

Small-Signal Modeling of CLLC Bidirectional Resonant Converters

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CLLC bidirectional 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.

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.

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.

P1333

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 (SCMLI) 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 details. Afterward, a modulating strategy called Multicarrier Sinusoidal Pulse Width Modulation (MC-SPWM) is introduced in order to yield a 9-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, SCMLI, Active switches, Voltage stress, MC-SPWM; MATLAB simulation.

P1509

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 to validate the effectiveness and correctness of the virtual resistor control scheme.

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

P1281

Optimization Design of Doubly Salient Electro-Magnetic Motor under Fault-Tolerant Operation of Excitation Fault

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Excitation fault is troublesome because it takes a negative impact on the overall performance of the doubly salient electromagnetic machine (DSEM).The output torque of DSEM 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 DSEM 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 DSEM in the state of loss of excitation were analyzed. A 12 8-pole finite element analysis model of DSEM is established.The different stator pole, stator yoke, rotor pole, rotor yoke and air gap of the motor were simulated. The influence of the structural parameter changes on the electrical and magnetic characteristics of the motor was studied.The number of turns of DSEM winding suitable for loss of excitation fault-tolerant operation was designed and simulated.

Keywords: Structural parameters, DSEM, Finite element analysis, Excitation fault.

Session [TT24] TT24: Power Electronics (VII)

P1042

High-Frequency Signal Injection using Extend State Observer for Position Sensorless PMSM Drives

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In sensorless vector control of Permanent Magnet Synchronous Motor (PMSM) drives, it is important to obtain accurate rotor position. High-frequency (HF) voltage injection method is usually used to estimate the rotor position of the motor at low speed. However, the use of the digital filter reduces the estimation accuracy of the rotor position. In this paper, an improved signal processing method based on the HF square-wave voltage injection method is used to obtain the rotor position error signal. A third-order extended state observer (ESO) is used to estimate the rotor position and speed. Compared with the traditional sensorless control strategy, the proposed method reduces the use of the digital filter, simplifies the signal processing, eliminates the influ-

ence of the inverter nonlinearity on the accuracy of rotor position estimation and improves the dynamic performance of the system. Experimental results are provided to verify the effectiveness of the proposed method.

Keywords: Permanent Magnet Synchronous Motor (PMSM), Sensorless, High-Frequency (HF) Square-wave voltage injection, Extended State Observer (ESO).

P1053

Fundamental PWM Excitation Based Low-Speed Sensorless Control Method for PMSM Drives

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Signal injection methods have been highly applied in sensorless control system of interior permanent magnet synchronous motor (IPMSM) drives. However, there are inherent disadvantages of signal injection methods which are additional torque ripple and high frequency audible noise. In this paper, a rotor position estimation method is proposed by detecting the derivative of phase currents. The rotor estimation based on rotor saliency-tracking technology shows a good performance in the low-speed motor operation region. Compared with the signal injection method, the proposed method is more suitable for a noise-free working environment.

Keywords: Interior Permanent Magnet Synchronous Motor (IPMSM), Sensorless control, Low speed, PWM, Current derivative method.

P1205

Economic Optimization Model of Islanded Microgrid Considering the Benefit of Energy Storage Charge and Discharge

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This paper presents a novel optimization model to address the real-time economic dispatch problem of islanded microgrid. The model fully considers the energy storage system(ESS)'s acquisition cost in the past period and operational benefit in the future period, to determine the appropriate energy dispatch of an ESS unit in the current period. In addition, Each unit in the microgrid(MG) maximizes its own operational benefits only need to exchange expected electricity price and transaction power with neighboring unit. After optimization, the neighboring units participated in economic dispatch can achieve consistency of electricity price and transaction power at the same time. In order to obtain the optimal solution, the alternating direction multiplier method (ADMM) is introduced to solve this problem. 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.

Session [TT25] TT25: Power Electronics (VIII)

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 submodels 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 Threephase 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.

Keywords: Transformer impedance, Power loss, Photovoltaic power station.

P1208

Performance Analysis and Comparison of Two Kinds of Double-Layer Permanent Magnet Synchronous Motors

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With permanent magnet synchronous motor (PMSM) based on new energy vehicles, using the finite element software established the double-layer "I" type (2I) and the structure of the double-layer "V" type (2V) motor model, compares the two kinds of rotor structure of d-q axis inductance, output torque and reluctance torque performance, analyzes the two kinds of topological structure of the flux weakening speed expansion performance and the factors affect the ability of the flux weakening speed expansion performance. According to the characteristics of the rotor topological structure, the applicable operating conditions of the two rotor topological structures are analyzed.

Keywords: PMSM, Rotor topology, d-q axis inductance, Flux-weakening ability, Finite element method.

P1414

Research on Impact of Distributed Photovoltaic Grid Connection on Three-section Current Protection Strategy of Distribution Network

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This paper studied the impact of photovoltaic access on TSCPS of distribution networks through theoretical analysis and simulation verification. Firstly, the active distribution network structure with photovoltaic access and the corresponding control strategy are described. Then, taking a typical scenario with an IEEE33 nodes distribution network as an example, the analysis of the influence of photovoltaic access on short-circuit current was carried out, and a corresponding simulation model in MATLAB / Simulink to simulate the impact of photovoltaic access on short-circuit current and load current was built. Finally, the setting criteria of three-stage current protection parameters in typical scenarios were proposed. The researches in the paper can provide a reference for the subsequent research on improving the quality of grid connection. *Keywords:* Three-stage current protection strategy, Distributed photovoltaic power generation, Medium and low voltage distribution network.

P1615

A Two-stage Model Predictive Control Strategy for Economical Operation of Microgrid

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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 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.

P1192

Stiction Fault in MEMS Comb Drive Resonator

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MEMS devices are vulnerable to various defect sources, such as point stiction, broken-beams, etch variation. Point stiction is the defect in which the movable parts of the device is stuck to the substrate or fixed parts at one or multiple point locations. Point stictions may affect the yield as well as the reliability of MEMS devices. Fault simulation is an effective way to study how the point stiction defects will affect the device yield and reliability. For point stiction defects, the occurrence and the location are random and cannot be precisely predicted. Such stochastic behavior can be better predicted with the Monte Carlo simulation. Monte Carlo simulation is a stochastic technique used to approximate the probability of specific outcomes by running multi-

ple trial simulations using random numbers and probability statistics. In this paper, the ANSYS Monte Carlo simulation is used to simulate point-stiction defects in surface-micromachined MEMS comb resonator devices. The yield of MEMS devices is estimated based on the simulation results. The fault simulation in MEMS devices is essential to optimize the device performance and to improve the yield and reliability of MEMS devices.

Keywords: MEMS, Resonator, Point Stiction, Monte Carlo simulation.

P1244

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 duringspark 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 workstation. 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 pulsed power suply, CAN bus, adaptive control.

Session [TT26] TT26: Power Electronics (IX)

P1588

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 influences 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

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.

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 researches on output control methods of the receiver-side boost converter. It is found that direct output control brings in 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 charging 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.

P1291

Modeling and Stablility 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 (PCMcontrolled) 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 continue 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), PCMcontrolled, Accurate discrete iterative map model, Dynamic phenomenon.

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 digest, 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.

P1304

Optical Method Based Detection and Wavelets Based Processing of Acoustic Waves

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Acoustic waves (AW) has 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] TT27: 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 microscope (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.

P1598

Dynamic Regret Analysis for Online Tracking of Time-varying Structural Equation Model Topologies

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Identifying dependencies among variables in a complex system is an important problem in network science. Structural equation models (SEM) have been used widely in many fields for topology inference, because they are tractable and incorporate exogenous influences in the model. Topology identification based on static SEM is useful in stationary environments; however, in many applications a time-varying underlying topology is sought. This paper presents an online algorithm to track sparse time-varying topologies in dynamic environments and most importantly, performs a detailed analysis on the performance guarantees. The tracking capability is characterized in terms of a bound on the dynamic regret of the proposed algorithm. Numerical tests show that the proposed algorithm can track changes under different models of time-varying topologies.

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 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 vessels objects shade to what lead to the loss of the early warning, lost ship call based on the

twin of the neural network for retrieving the lost ship detection module, continue to use the tracking module tracking target ship, the ship for a long time tracking under complex environment. Experimental results show that the tracking results of this algorithm are more accurate and real-time than those of typical algorithms.

Keywords: Ship tracking, Multi-scale, Re-detection.

P1470

A Novel Method based on Character Segmentation for Slant Chinese Screen-render Text Detection and Recognition

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Screen rendering text has broad application prospects in the fields of medical records, dictionary screen capture, and screen-assisted reading. However, Chinese screen rendering text always has the challenges of small font size and low resolution. Obtaining a screen-rendered text image in a natural scene will have a certain tilt angle. These all pose great challenges for screen text recognition. This paper proposes a method based on character segmentation. In order to correct the tilt of the text image, a lightweight image text correction method is proposed. In order to obtain better character segmentation accuracy in extreme environments, a Gaussian extremum removal module is designed. Drawing on HCCR-GoogLeNet, a simple and efficient network architecture is designed for character recognition. Finally, this paper will slant text correction, horizontal text line detection, character segmentation, and character recognition to construct a complete network architecture to be applied to the screen rendering text recognition process scheme in natural scenes. The character recognition model was evaluated on ICDAR2013 and the homemade screen rendering dataset, and both achieved good results.

Keywords: Optical character recognition, Character segmentation, Slant text detection.

P1146

Sleeper Defect Detection Based on Improved YOLO V3 Algorithm

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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, Kmeans, Multi-scale training.

P1151

Detection Method of Track Locating Point Based on Yolo V3

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This paper presents a method to determine the position of the train in the track by detecting the track locating points, and establishes the image data sets of the track locating points. Because the locating points on each track are unique, the number of locating point image samples is very small, which poses a great challenge to the accuracy of locating point detection. We apply the target detection algorithm of Yolo V3 to the field of track location point detection, and propose three improvements. Firstly, the training data sets are expanded by data enhancement of images. Then K-means clustering algorithm is used to analyze the size of the anchor boxes of the data sets, and new clustering centers are obtained. Finally, the multi-scale training method is used to make the model adapt to images of different resolutions. The results indicate that compared with the original network, the improved Yolo V3 model not only has better adaptability to image detection with different quality and resolution, but also has higher mean average precision and better detection effect.

Keywords: Track locating, Target detection, Yolo V3, Cluster analysis.

Session [TT28] TT28: Signal and Information Processing (II)

P1292

GPU-Based Occlusion Minimisation for Optimal Placement of Multiple 3D Cameras

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This paper presents a fast GPU-based solution to the 3D occlusion detection problem and the 3D camera placement optimisation problem. Occlusion detection is incorporated into the optimisation problem to return near-optimal positions for 3D cameras in environments containing occluding objects, which maximises the volume that is visible to the cameras. In addition, the authors' previous work on 3D sensor placement optimisation is extended to include a model for a pyramid-shaped viewing frustum and to take the camera's pose into account when computing the optimal position.

Keywords: 3D sensor, Optimal placement, Occlusion, CUDA.

P1058

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

P1056

A Dual-Channel Design in Microfluidic Chip for Label-Free Detection by Quasi-Bessel Beam

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Scattering signals in microfluidic chips 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 smallangle 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.

P1098

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

ability. The method proposed in the paper can meet online measurement of penicillin mycelium concentration in the fermentation process, the method is an effective for soft sensing.

Keywords: Bio fermentation, Penicillin, Support vector machine regression, Soft sensing, Nonlinear, Model, Predict.

P1097

GNSS Receiver Satellite Selection Algorithm Based on Particle Swarm Optimization

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The multi-constellation integrated navigation system increases the number of visible satellites, improves positioning accuracy, and increases the computational burden of the receiver. An effective algorithm needs to be proposed to use a subset of satellites to replace all-in-view satellites and ensure positioning accuracy. In this 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 multiconstellation 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.

P1223

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).

Session [TT29] TT29: Signal and Information Processing (III)

P1022

Damage Identification of a Jacket Support Structure for Offshore Wind Turbines

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Offshore jacket structures are regarded as a suitable type of support structure for offshore wind turbines in immediate water depths. Because of the welded tubular members used and environmental conditions, offshore jackets are often subjected to fatigue damages during their service life. Underwater sensors can provide measurements of the structural vibration signals and provide an efficient way to detect damages at early stages. In this work, simplified forms of the damages are assumed, random damages are imposed on the jacket structure, and damaged indicators are established from combination of modal shapes. Then, a response surface is constructed mapping the damage indicators and damages. Given that the efficiency of the damage identification depends on the locations of the damages and the location and number of sensor locations, a sensitivity study is performed to vary sensor location, sensor quantity, and damage severity. It is found that the effect of damage identification is better when sensor locations are closer to damage locations, and this effect is more sensitive to sensor placements when damages occur in the upper structures. Additionally, the identification effect is more sensitive to damage severity than to occurrence of multiple damages.

Keywords: Damage identification, Jacket, Structural modal analysis, Artificial neural network, Sensor.

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. These 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 $4 \times 10^4 m^3/d$ to $20 \times 10^4 m^3/d$ 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 development 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-

Huang Transform. The nonlinear characteristics of a structure can play a significant role in its behavior or response to stimuli. Thus, knowing these characteristics can lead to better design analysis and predictions of system responses.

Keywords: Signal processing, Hilbert-Huang transform, Harmonics tracking method.

P1370

Development of Portable Balance Rate Tester for Sucker Rod Pumping Unit

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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.

P1439

Radar Emitter Signal Sorting Method Based on Density Clustering Algorithm of Signal Aliasing Degree Judgment

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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.

Session [TT30] TT30: Signal and Information Processing (IV)

P1630

Detection of Major Depressive Disorder using Signal Processing and Machine Learning Approaches

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Depression is accorded as one of the leading causes to all the problems related to mental health in the Global disease burden (GBD) study. *Major Depressive Disorder* (MDD) is when this depression reaches to a larger extent, when depression persists for two weeks or more. Sadly, many individuals of our society tend to neglect depression and refuse to label it as a mental disease and has a tendency to not seek medical help. Not only this, they are being curbed because of the few or very limited biological indicators for depression identification. Our main objective is to develop a non-intrusive approach that will detect and differentiate brain signals of patients with MDD from healthy patients. We were able to obtain an optimized model with an accuracy of (82%). Primarily, we obtained a raw EEG dataset upon research and performed noise removal on them. Afterwards we extracted relevant features for depression detection. Finally, we entered these features into three classification algorithms such as Logistic Regression (LR), *Support Vector Machine* (SVM), and *Naive-Bayes* (NB) classifier. To check the accuracy and precision, we performed a ten-fold cross validation on them. Hopefully, our results will encourage and motivate people suffering from this to seek the proper and effective medical help and to eradicate the negative stigma around it.

Keywords: MDD, Absolute delta power, LR, SVM, NB, EEG.

P1542

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 some advantages 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 new 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 detect metallic materials, a denoising method combining empirical mode decomposition (EMD) with local entropy is proposed for flaw echo denosing. In this method, The Intrinsic Mode Functions (IMFs) components and residual components of ultrasonic signal were obtained through the EMD method. A Similarity Measure method were used to select the signaldominant modes. Then, the local entropy of the first signaldominant 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 denosing was obtained by accumulating defect echoes and residual components. Denoisng 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 of 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 H_2 and H_{inf} Approach for Placement of Piezoelectric Actuators and Sensors on Curved Surfaces in Actively Controlled Structures

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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 modelbased 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_∞ norms constructed upon the eigenforms 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_∞ norm, Actuator and sensor placement, Piezoelectric smart structures.

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 OSLR 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.

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. This algorithm has been compared with the existing techniques proposed for mesh topology counterparts. The experimentations 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.

P1297

Research on Visual Performance Evaluation Model of E-commerce Websites

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With the growth of users' personalized demand for e-commerce visual design and the rapid development of machine learning technology, a large number of Inter-

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.

P1054

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.

Session [TT32] TT32: Artificial Intelligence (I)

P1575

Channel-Wise Part-Based Weighting Aggregation for Image Retrieval

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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.

P1228

Detecting and Tracing Multi-Strategic Agents with Opponent Modelling and Bayesian Policy Reuse

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In competitive multi-agent scenarios, the agents try to defeat their opponents by choosing the best response policies. However, non-stationary opponents make it difficult because they can also adapt to the evolved policies and behaviors of the agents. In this paper, we propose a novel Bayesian policy reuse approach for non-stationary opponents. It combines the learning of the best policy, the detection and prediction of the opponent policy, as well as the selection of the optimal response policy. We introduce an eXtended learning classifier system (XCS) for multi-agent reinforcement learning algorithm in Markov games. Besides, we incorporate the opponent models for opponent policy identification and prediction. Furthermore, we propose a novel online policy reuse technique which can accurately and quickly trace the opponents' policies in tasks with different rewards. We demonstrate the performance of the proposed approach by comparing it with state-of-art existing algorithms in competitive Markov games.

Keywords: Markov games, Opponent modelling, Bayesian policy reuse, Learning classifier system, Reinforcement learning.

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-

mental results on an industrial robot demonstrates the effectiveness of the proposed framework in the identified use case.

Keywords: Machine learning, Cognitive analytics, Anomaly detection, Machine health monitoring, Predictive maintenance.

P1532

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.

P1629

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 on the Open Access Series of Imaging Studies (OASIS) dataset. The main contribution of the paper is a 12-layer CNN model with an accuracy of 97.75%, which is higher than any other existing CNN models published on this dataset. The paper also shows side by side comparison between our proposed model and pretrained CNN models (InceptioV3, Xception, MobilenetV2, VGG). The experimental results show the superiority of the proposed model over the existing models.

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

P1198

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 converting sequences of graphemes to sequences of phonemes. This is an important issue in both text-tospeech 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 a 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.

Session [TT33] TT33: Artificial Intelligence (II)

P1452

Research on Fault Diagnosis of Flight Control System Based on SVM Optimization

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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 difference between. 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 SVMAdaboost 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.

P1556

Transfer Learning in General Lensless Imaging through Scattering Media

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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 antiinterference. 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 scattering 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.

P1182

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 technique. The localization of UAV plays an important role in anti-UAV system. 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), Naïve Bayes, decision tree (DT), K nearest neighbors (KNN) and random forest (RF), are designed to estimate the coordinate 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 Featurerecalibration (FR) Networks, that adaptively recalibrates channelwise 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 contexts 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.

P1213

CFCSS : Based on CF Network Convolutional Seq2Seq Model for Abstractive Summarization

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Aiming to provide automatic document summarization model with channel dependency and global information to capture deeply text architecture and semantic content, this paper puts forward a method based on CF Network convolutional Seq2Seq model for abstractive summarization(CFCSS). The input of this method is combined with the position vector so that the model architecture can obtain the position information. At the same time, the residual network block and multi-step attention mechanism are used to model key information. In addition, this paper uses gated linear units(GLU) for nonlinear calculation and Copy mechanism to solve rare words problems. Finally, the validity of the model is verified on CNN/Daily Mail corpus, and the results show that the proposed model outperforms than the state-of-the-art methods with consistent substitution and significant statistical significance.

Keywords: Position information, Multi-step attention mechanism, Residual network, GLU, Copy mechanism.

P1264

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-

tor method for solving the control system synthesis problem. The general synthesis problem statement is formulated with regard to its numerical solution. Complexity of the numerical solution of the general problem of control synthesis includes the necessity to find a multidimensional control function so that the control object from any initial state of some area falls into a terminal state with the optimal value of the quality criterion. The work uses the network operator method to solve the control synthesis problem. The method allows to find a solution in the form of an encoded mathematical expression with the help of special genetic algorithm. An example of quad-copter stabilization system synthesis by the network operator method is considered.

Keywords:
Control system synthesis, Quad-copter, Genetic algorithm, Symbolic regression.

Session [SS01] SS01: Invited Session on Autonomous vehicle state-of-the-art, challenges and future road map & Invited Session on Distributed Renewable Energies: Modeling, Planning, Regulation and Application

P1303

Autonomous Mooring towards Autonomous Maritime Navigation and Offshore Operations

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Bollard is a vital component of mooring system. It is the anchor point for mooring ropes to be fixed in order to secure the vessel or ship. An algorithm that translates the segmented mask of bollard output from masked R-CNN along with bounding box and associated class probability to its corresponding edge coordinate and finally to the single reference point for efficient detection and classification of bollard towards autonomous mooring is presented. At first stage, Mask R-CNN framework is trained with custom built bollard. The model obtained from the training is inferred with real data resulting in instance segment of bollard. The segmented mask obtained contains relatively large amount of the data points representing the whole area of bollard, which typically is not desirable. In order to precisely localize the bollard with one reference co-ordinate, the proposed algorithm is applied to segmented mask. Firstly, it translates the segmented mask to only four co-ordinate points, where each point correspond to the edge of bollard. Further, from the edges, the reference point is estimated. This causes significant reduction in point of interest (POI) and has potential to reduce the error encountered during pose estimation of the bollard in 3D thus making the autonomous mooring more precise and accurate.

Keywords: Instance segmentation, Autonomous mooring, Mask R-CNN, Object detection and classification.

P1490

Camera-LiDAR Data Fusion for Autonomous Mooring Operation

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The use of camera and LiDAR sensors to sense the environment has gained increasing popularity in robotics. Individual sensors, such as cameras and LiDARs, fail to meet the growing challenges in complex autonomous systems. One such scenario is autonomous mooring, where the ship has to be tied to a fixed rigid structure (bollard) to keep it stationary safely. The detection and pose estimation of the bollard based on data fusion from the camera and LiDAR are presented here. Firstly, a single shot extrinsic calibration of LiDAR with the camera is presented. Secondly, the camera-LiDAR data fusion method using camera intrinsic parameters and camera to LiDAR extrinsic parameters is proposed. Finally, the use of an image-based segmentation method to segment the corresponding point cloud from the fused camera-LiDAR data is developed and tailored for its application in autonomous mooring operation.

Keywords: Autonomous mooring, Camera calibration, LiDAR calibration, Sensor fusion.

P1499

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.

P1131

Research on Calculation Method of Line Loss in Distributed Transformer Area Considering Uncertainty of Distributed Photovoltaic Output

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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.

P1132

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 gridconnected 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 power grid 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 po-wer generation, Energy storage unit.

P1559

Mechanism 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.

Session [SS02] SS02: Invited Session on Advanced Control Technologies For Power Electronics and Applications

P1218

Feasibility Analysis of Energy Storage System as Black-start Power Sources for Power Grid

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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.

P1294

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, Large-signal stability, Decentralized control, Adaptive control, Renewable energy sources, Constant power load.

P1321

Optimal Modeling of Integrated Energy Demand Response under Time-Shared Electricity Price

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Peak-valley time-of-use tariff is an effective pricebased demand response strategy. Through reasonable time-of-use tariff, energy demanders can provide sufficient and efficient price signals, so as to achieve the goal of peak-filling of energy demand. The integrated energy system combines electricity, heat, cold, gas and other energy forms, and can achieve economic dispatch among different energy forms through a certain dispatching strategy. In this context, firstly, the energy hub modeling technology is used to achieve the effective modeling of the participating units in the integrated energy system. Secondly, the traditional research on demand response for electric load is extended to the research on demand response for cold and hot load, and a comprehensive energy demand response model including demand response for electric, thermal and cold load is established. The model is solved by using YALMIP/CPLEX optimization solver based on MATLAB platform. Finally, the simulation results of different scenarios show that considering the comprehensive energy demand response in the context of time-sharing tariff is not only conducive to load peak-shaving and valley filling, but also has a certain role in improving the dispatching economy of the system.

Keywords: Time-sharing tariff, Price-based demand response, Multiple energy forms, Energy hub, Integrated energy demand response.

P1327

An Optimal Allocation Method for Multi-Agent Joint Capacity of Microgrid

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With the rapid development of environmental technologies such as renewable energy, smart grid, and electric power 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-

mization method. Research objectives include: 1) minimizing costs; 2) reducing greenhouse gas emissions; 3) reducing waste energy. This research can provide strong support for decision-making, analysis and strategy-making of multi-agent joint microgrid capacity.

Keywords: Microgrid, Optimization, Renewable energy, Electric vehicles, Hybrid power generation.

P1328

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.

Keywords: Primary frequency modulation, Energy storage system, Amplitude-frequency characteristics, Model simplification.

P1379

Distributed Nonconvex Economic Dispatch Algorithm for Large-Scale Power System

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This paper proposes a distributed genetic algorithm to solve 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 scenario.

Keywords: Distributed genetic algorithm, Non-convex optimization problem, Average consensus, Economic dispatch, Power system.

P1314

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.

Keywords: Current controller, Grid-connected inverter, Lyapunov function, Dynamic response.

Session [SS03] SS03: Invited Session on Power Converters for Energy Router: Topologies, Advanced Control Strategies and Applications

P1329

Power Flow Analysis of Three-Port Resonant DC Transformer And Discussion on Phase Shift Control

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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 has 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.

P1330

I&I Adaptive Based Backstepping Passive Coordination Control of STATCOM and Generator Excitation

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This paper presents a new coordinated control strategy using immersion and invariant (I&I) adaptive and backstepping passive control for STATCOM and generator excitation in order to conquer the influence of the uncertain damping coefficient and external disturbance on the system stability. 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.

P1332

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

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In the energy storage system, a DC/DC converter is usually deployed to ensure the wide range of voltage gain, to guarantee the life-span of battery, as well as to improve the efficiency, which puts a challenge on the seamless switch of charging modes. Therefore, a high-efficiency oriented control method is proposed for bidirectional resonant DC/DC converter based on the features of energy storage system. In the charging mode, the constant current (CC) and constant voltage (CV) schemes are combined together to properly adapt the changing equivalent inner resistance of battery. In the discharging mode, the output DC voltage of converter remains unchanged by regulating switching frequency to avoid the disturbance on the DC bus. The simulation using xx platform/software has been developed to verify the feasibility and superiority of the proposed method.

Keywords: Battery charger, Energy storage system, CLLCDCT, Constant Current (CC) Charge, Constant Voltage (CV) charge.

P1407

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 tolerate regulation performance, the proposed ET-MPC 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.

P1449

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

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A model predictive control based on event-trigger (ETMPC) is presented for three-phase Vienna rectifier in this paper. The event-triggered condition of the ETMPC for threephase 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.

P1523

Design and Implementation of Charging Pile in a Router-type DC Charging Station

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In order to solve the problem of low charging power and efficiency of the charging piles for electric vehicles, a novel design scheme is proposed in parallel router-type highpower DC charging stations. Compared with existing design approaches, the proposed design scheme is more efficient and flexible with the consideration of the different parameters and requirements of the battery to be charged. The experimental results show that the proposed design scheme helps improve the power and charging rate of the charging device.

Keywords: Electric vehicles, DC charging device, Charging strategy.

Session [SS04] SS04: 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, 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 estimation strategy is addressed. A simulation example is presented to show the validity and effectiveness of the proposed approach.

Keywords: Geometric approach, Fault detection and isolation, Fault estimation, Partial disturbance decoupling.

P1147

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.

P1177

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 error 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 underactuated stratospheric airship model is presented. Secondly, the threedimensional 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: Strarospheric airship, Spatial descent, Vector field guidance, Terminal sliding mode control.

Session [SS05] SS05: Invited Session on Advanced Control Methodologies for Uncertain Dynamical Systems with Industrial Applications (II)

P1286

Event-Based Formation Control for Linear Multi-Agent Systems Under Switching Topology

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This paper investigates linear multi-agent systems under switching topology. A novel event-triggered consensus formation controller is proposed. Sufficient conditions are presented to ensure the boundedness of formation error. Zeno behavior can also be avoided in the event-triggered mechanism. A numerical simulation based on hexagon formation of six robots is carried out to validate the results.

Keywords:
Event-triggered mechanism, Multi-agent system-s, Formation control, Switching topology.

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 eifects 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 dosed-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 eifect of intermittent actuator faults on the system stability of each agent, a local parameter estimator is introduced

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.

P1620

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, Timevarying parameters.

P1275

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 closedloop system is globally stable. Simulation results of three-agents with input saturation shows the effectiveness and performance of the proposed method.

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

Session [SS06] SS06: Invited Session on Advanced Control and Topology for Railway Traction Drive System

P1128

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.

P1130

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

P1136

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.

P1194

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.

P1252

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, and not only smooth torque production but also the highest possible efficiency drive can be achieved without preliminary tuning. Compared with the traditional DITC, the proposed DITC with adaptive excitation angle can achieve the widest operating range. The effectiveness of the proposed strategy is evaluated by performing simu-

lations on a 12/8 SRM.

Keywords: Switched reluctance motor, Excitation angle control, Torque ripple, Direct instantaneous torque control.

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 antiinterference 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 gridconnected 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] SS07: Invited Session on Power Electronics Application Technologies in Rail Transit: Intelligent Interface Design, Advanced Control Strategies, Modelling and Reliability

P1224

Modeling and Simulation of Straddle-type Monorail Vehicle Adhesion Control

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As a new type of urban rail transit, the straddletype 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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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 (three 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 neutralpoint-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 Virtural Damping Resitor

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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 pseudolinear 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 resister in series with line inductor. Based on the inverter power control, q-axis current is obtained. Simulation results show that the active damping method effectively suppresses dcŰlink oscillation and improves the stability of MTDS. *Keywords:* Active damping stabilization scheme, Negative impedance, PL-EPLL, Virtual damping resistor, Metro Traction Drive System (MTDS).

P1383

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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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] SS08: 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 wellestablished KPI metrics 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 MOTA 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 video.

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.

P1534

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 manyto- 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.

P1423

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 towards target. This paper discusses the classification performance of FM methods and its extensions to manufacturing processes and other industry fields. Real-world datasets are employed for the validation of classification performance. Experimental results show that FM-based approaches efficiently improve the classification accuracy about 2.49%-5.94% compared with conventional classification methods.

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

Session [SS09] SS09: Special Session on Advanced Mechatronics in Offshore Systems

P1164

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 perceptron 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.

P1312

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

images to train and test these algorithms are publicly available. Furthermore, most of these datasets do not include species that are related to aquaculture. Big datasets of images are usually created manually, which can be highly time consuming. This paper presents preliminary results of a system developed to create large image datasets of fish species semi-automatically. The system combines simple techniques of image processing with the state of the art of deep neural networks in an iterative process to extract, label and annotate images from video sources. In order to validate the system, video samples were taken inside and outside cages of a fish farm in Norway. A set of experiments were conducted for two species: salmon and saithe. A small dataset of 200 images for each of the species, as a test case, was successfully created.

Keywords: Image datasets, Fish detection, Object recognition, Marine aquaculture applications.

P1343

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 way, it could speed up the learning efficiency by extracting more information from available experience. To verify the effectiveness of the proposed integrated simulation framework, in this study, we implemented the proposed DSS in ship docking operation under various environmental disturbances. It is interacted with the simulator to obtain data. By processing these data, it provides the shipmaster with the information about the consequences of the ship maneuvering decisions. The simulation results demonstrate that the proposed DSS could assist the shipmaster in deciding policies and increase the efficiency of decision making.

Keywords: Ship docking, Decision supporting 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 thus 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.

P1581

GPU-Based Optimisation of 3D Sensor Placement Considering Redundancy, Range and Field of View

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This paper presents a novel and efficient solution for the 3D sensor placement problem based on GPU programming and massive parallelisation. Compared to prior art using gradient-search and mixed-integer based approaches, the method presented in this paper returns optimal or good results in a fraction of the time compared to previous approaches. The presented method allows for redundancy, i.e. requiring selected sub-volumes to be covered by at least n sensors. The presented results are for 3D sensors which have a visible volume represented by cones, but the method can easily be extended to work with sensors having other range and field of view shapes, such as 2D cameras and lidars.

Keywords: 3D sensor, Optimal placement, CUDA.

Session [SS10] SS10: Invited Session on Advanced techniques towards more electrified and intelligent mobility

P1530

Lithium-Ion Battery Parameter Identification and State of Charge Estimation based on Equivalent Circuit Model

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Electric vehicles (EVs) have developed rapidly in the face of critical problems of climate change, resource scarcity and environmental pollution, while lithium-ion batteries (LIBs) have been widely used as the onboard power source of EVs. As a key state in the battery management system (BMS), state of charge (SOC) not only defines the safety margin of battery to avoid overcharge/ discharge, but also underlies the system-level energy management. This paper proposes an online adaptive model-based SOC estimator. This method combines the Thevenin battery model, the recursive least squares (RLS) algorithm and the extended Kalman filter (EKF) algorithm to accomplish parameter identification and SOC estimation in a cascaded manner. Simulations and experiments are performed to evaluate the proposed method. Results suggest that the proposed method can effectively track the change of model parameters, and thus estimate the SOC accurately in real time.

Keywords:
Lithium-ion battery, Online estimation, Parameter identification, State of charge, Equivalent circuit model.

P1555

Learning based Predictive Error Estimation and Compensator Design for Autonomous Vehicle Path Tracking

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Model predictive control (MPC) is widely used for path tracking of autonomous vehicles due to its ability to handle various types of constraints. However, a considerable predictive error exists because of the error of mathematics model or the model linearization. In this paper, we

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 estimation 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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Chang'e-4 lunar lander and "Yutu-2" rover safely landed on the farside of the Moon on 3rd, Jan., 2020. It is the first unmanned spacecraft to softly land on the lunar farside and carried out in-situ and rover exploration there. However, the lunar farside is beyond the communication range of the ground stations on the Earth due to the synchronous rotation of the Moon. Therefore, how to implement reliable relay communication between the Earth and the Moon is crucial for the whole mission. The relay satellite "Queqiao" was launched and is orbiting around the lunar Lagrange point 2 stably for over a year, which is to setup relay communication link between the lunar farside and the Earth. A high-gain antenna (HGA) configured on the lunar lander is utilized in Chang'e-4 lunar mission for transmitting scientific data collected on the lunar farside to the relay satellite and the data is send back to Earth via the relay communication link. Whereas errors such as the positioning and landing attitude error, pointing error of the HGA, timing difference etc. may influence the accuracy of lunar lander-relay satellite antenna acquisition and tracking thus may cause the interruption on communication link.

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 criterions 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

27.18%), respectively. The berth occupancy rate of less utilized buffer terminals is also improved from 21.39% to 38.35%.

Keywords: Big data, Automatic identification system, Scheduling, Optimization algorithms, Maritime KPIs.

P1587

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.

Session [SS11] SS11: Invited Session on Modelling and Control of Robots

P1375

Self-Calibration of Wearable Upper Limb Cabledriven Exoskeleton

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Cable-driven parallel robots (CDPRs) is an important branch of rehabilitation exoskeleton. Due to the non-rigid character of CDPRs, the geometric parameters of CDPRs are greatly deviated. Therefore, it is necessary to carry out geometric calibration of cable-driven rehabilitation exoskeleton. At present, there are still many difficulties in the geometric calibration of wearable upper limb cable-driven exoskeleton. This is because the body has the individual diversity and flexibility, and the motion system composed of the human body and the exoskeleton is more uncertain than the anthropomorphic robot arm. Aiming at this problem, an adaptive calibration method for upper limb cable-driven rehabilitation exoskeleton based on Newton-Raphson iteration was established, and the model of human-exoskeleton motion system were optimized in this paper. The adaptive calibration of human-exoskeleton motion system is realized for the first time. Experimental results show that this method can effectively improve the motion control accuracy and humanexoskeleton interaction experience.

Keywords: Cable-driven, Rehabilitation exoskeleton, Novel calibration, Identification.

P1376

Experimental Implementation of Collective Motion based on Swarm Robotic Control

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Collective behavior is now observed commonly in animal groups, while there is still a giant gap between theoretical research and implementation on the on real swarm robotic systems. Collective motion is a kind of consensus behavior in which robots show self-organized aggregation and alignment. Different from the shape formation of a swarm of robots in a fixed speed, the collective motion requires

each robot to change its both linear and angular speed spontaneously. We adapt a decentralized algorithm which has the similar interaction method with animal group to the collective motion of swarm robotic control, considering the physical limits of the robots. Using e-puck robots, we show that the algorithm can make the robots aggregate and align with each other automatically on the condition of a bounded circle scenario.

Keywords: Collective behavior, Swarm robotics, Aggregation, Alignment.

P1386

Comprehensive Characterization Method of Faulttolerant 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 single 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 underactuated 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.

P1607

Adaptive Locomotion of Lower Limb Exoskeleton Based on Oscillators and Frequency Adaptation

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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 performers 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

domain features of the signals without any prior information by Residual Blocks, and fuse these features by attention blocks. In order to reduce the risk of overfitting, we use the Batch Normalization layer, Global Average Pooling, and Additional Random Noise to improve robustness. The proposed algorithm has a classification accuracy of 95.6% with only 20 samples per category when the SNR is 20dB, which outstrips other classical methods under the same condition.

Keywords: Automatic modulation classification, Wavelet decomposition, Attention block, Small sample size problem.

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 pixellevel 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 conductive to semantic segmentation for indoor scenes.

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

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 programed 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 int8 quantized Mobile NetSSD 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

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.

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.

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

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.

P1346

Dynamic Modeling and Control Methods of a Novel Electromagnetic-Driven Spherical Motion Generator

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In this paper, we present the prototype of a novel spherical motion generator driven by an electromagnetic force. It is such a mechanism that combines the structure of a spherical parallel manipulator with the actuation of the spherical motor. To accomplish the task of trajectory tracking, we firstly employ the Lagrange-D'Alembert equation to establish the dynamic model. Due to the nonlinearity of the system, we attempt to apply three different control methods to compare their performances. Simulation model is formulated by Matlab/Simulink and the experimental results demonstrate that all control strategies can almost achieve the goal of trajectory tracking. The computedtorque method (CTM) has a better trajectory tracking performance than the others in the presence of friction for that it makes use of the dynamic information and converts a nonlinear system into a linear one via full-state nonlinear feedback.

Keywords: Spherical motion generator, Trajectory tracking, Dynamic model, Matlab/Simulink, Computed-torque method.

P1359

Integration of Data Distribution Service into Partitioned Real-time Embedded Systems

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Data Distribution Service (DDS) middleware facilitates interoperability and portability of components by building the underlying communication network in mixedcriticality systems with real-time requirements, especially those in conformity with Future Airborne Capability Environment (FACE) technical standard. Partitioning is the key technology permitting applications with different levels of criticality to execute in a same hardware on strict isolation in time and space. A system architecture is proposed to realize the integration of DDS into partitioned real-time embedded systems compliant with ARINC- 653 specification. The architecture allows communications among applications through the DDS middleware, whether they are executed in a partitioned system or not. Then an Unmanned Aerial

Vehicle (UAV) combat scenario is simulated to exemplify the design feasibility. Evaluation tests show the communication stability can be obtained whether an ARINC-653 compliance system interconnect with heterogeneous systems or homogeneous systems. Based on the reliable configuration, the average communication time is stable at around 272.60μs in former situation and 281.32μs in the latter. And the specific performance difference between the two cases is further analyzed.

Keywords: Middleware, ARINC-653, Mixed-criticality systems, Data distribution service.

P1361

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.

P1362

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 pre research, test construction and process analysis, 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.

P1387

The Technology of Bus Network Communication for Space Environment

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The space battlefield environment is becoming increasingly complex. Multiple aircrafts often attack the same or different targets in cooperation when performing missions. The information of network interaction between aircrafts will determine the attack power of the whole system. In this paper, the SpaceWire bus with high bandwidth, high reliability, strong openness, good real-time and strong certainty is used as the inter vehicle bus, and a distributed inter aircraft bus network architecture is proposed. Through the modeling and Simulation, this paper analyzes the constraint parameters of bus network transmission under different conditions. It verifies the rationality and reliability of the design, and provides some reference for the practical application of bus network communication between aircrafts.

Keywords: SpaceWire bus, Distributed architecture, Inter aircraft bus network, Modeling and Simulation.

P1415

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.

Session [SS14] SS14: Special Poster Session (II)

P1436

Multi-Agent Cluster Systems Formation Control with Obstacle Avoidance

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For formation control and obstacle avoidance of multi-agent cluster systems, this paper proposes a new formation control and obstacle avoidance algorithm based on artificial potential field method, the advantage of which is that it can enhance the robustness of multi-agent systems and make the overall performance as no central control. Formation control adopts the follower-leader method. Leaders are not artificially designated, but selected by autonomous decision-making of multiagent systems. When the selected leader fails to continue to perform the task, the remaining followers can independently choose a new leader and form a new formation to continue the task according to the number of existing agents. Finally, the effectiveness of the proposed method is verified by a numerical simulation. The simulation results show that the algorithm proposed in this paper can perform no central formation control and obstacle avoidance for multi-agent systems.

Keywords: Artificial potential field, Formation control, Obstacle avoidance, No central control, Multi-agent systems.

P1457

A Robust SLAM towards Dynamic Scenes Involving Non-rigid Objects

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SLAM has achieved great progress over the past decades. Typical SLAM algorithms are based on the assumption that the observed environments are static. The strong assumption limits the use of visual SLAM systems in real-world scenes. In this paper, we propose a robust SLAM towards dynamic scenes involving non-rigid objects. We carry out instance segmentation to detect objects and refine the tracking by additionally extract static regions from non-rigid potential dynamic objects. Our method is evaluated on TUM RGB-D dataset. Experiments show that the proposed SLAM performs well in dynamic environments.

P1484

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

into full play, the effective utilization rate and usage cycle of hardware products could both be played to the maximized. So that software products of multiple generations can be compatible with a single type of hardware platforms. On the other hand, technical foundation for the realization of intelligent hardware product series can be layed, which is potentially promising.

Keywords: Reconfigurable technology, FPGA, SOC.

P1510

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 aerodynamics, stealth and optical performances can be obtained, and the risk for future research and production can be reduced significantly.

Keywords: Integrated canopy, CATIA, Optical angular deviation, Optical distortion, Simulation.

P1570

Visual Heart Rate Estimation from Facial Video Based on CNN

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Due to the advantages of non-contact and low-cost, visual heart rate (HR) estimation is attracting more and more scholars to research. Recently, Some studies have shown that deep learning method could be developed for visual HR estimation. In this paper, we proposed an End-to-end deep neural network method for this task. The network is consisted of 2D convolutional (Conv2D) and LSTM (long short-term memory) operations. The Conv2D operation extract spatial feature and LSTM capture temporal information. The input of our model is facial ROI video and output is the predict HR. Experiment demonstrate that the proposed method could estimate HR value precisely.

Keywords: Deep learning, Heart rate, Visual HR estimation, LSTM.

P1585

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.

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 effected noise is white 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 the noise in 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.

Session [SS15] SS15: Special Poster Session (III)

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 is 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, showes that the designed structure could realize two-degree-offreedom 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 threefactory study is conducted to determine the impact that the length, thickness of the actuator and the fluid pressure 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 the improved dynamic model are feasible and can meet the design requirement: velocity meet 13mm/s and swing frequency range from 0.25Hz to 0.5Hz.

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

P1367

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 costate of systems in virtue of the maximum principle. A necessary and sufficient condition for the optimal control problem is derived in terms of the two coupled Riccati equations.

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

P1373

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.

P1397

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 process 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 ATML), 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, Signaloriented.

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 twodimensional 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 Lithiumion 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 based on high sensitivity parameters is realized. The relative error of SOP/SOH estimation is less than 10% and 4%, respectively.

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 tack 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.

P1429

An Electrochemical Thermal Coupling Model for High Crate Conditions in 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 Crate 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.

P1430

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 offboard 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 buckboost topology enables lithium ion battery "self-heating", and the heating speed can be online regulated by controlling the switching frequency. In this paper, the modal analysis and simulation of the heating topology, and Set up a lowtemperature 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, Buckboost topology, Low temperature.

P1440

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.

P1451

A Half-bridge Strategy Based Fault-tolerant Control for BLDCM under Open Circuit Fault

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For open circuit fault of permanent magnet brushless DC motor(BLDCM) with trapezoidal back EMF, this paper proposes a half-bridge strategy based fault-tolerant control(FTC) method: by utilizing the current sensors to detect and locate the one-phase open circuit fault, adding a half bridge to the traditional full bridge drive circuit, and connecting it to the neutral point of the motor, so that the BLDCM can realize the fault-tolerant function under open circuit fault condition. The concrete content of this paper are as follows: First, the halfbridge based FTC schematic and theoretical analysis is introduced, then the BLDCM control model under normal and fault conditions are established in Simulink module for the analysis and comparison work, finally experiment work are performed to verify the effectiveness of the proposed control method under open circuit fault condition.

Keywords: BLDCM, Open circuit fault, Fault-tolerant control.

Session [SS17] SS17: Special Poster Session (V)

P1466

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.

P1486

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.

P1493

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.

P1503

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-

tering algorithm combined with cost function is applied to complete human target location in a 10m×10m detection area. The experimental results indicate the human locating system works well and the user can view the location information on the terminal devices.

Keywords: Internet of things, Wireless sensor network, PIR, Human target location.

P1528

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 information 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 image as 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 structure restoration 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.

P1558

Research on a Servo Control System for Flow Regulation

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Aiming at the problem of engine flameout caused by higher or lower air-fuel ratio, an electric servo system for engine gas flow regulation is designed. In view of the situation of large instantaneous load and short-term locked rotor that the servo system may encounter in the process of flow regulation, the control software is designed with various protection measures, and the incomplete differential PID control method is adopted to improve the system's anti-interference ability. The simulation results indicate that the system has the advantages of small volume, high output torque, fast response and good stability.

Keywords: Flow regulation, Electromechanical actuator, PID, Simulation.

P1616

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

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With the development of active distribution network, demand response, as an important adjustable resource, 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. This paper focuses on the analysis of two different types of demand response: incentive-based demand response and price-sensitive demand response, whose influence of uncertainty on costs is also considered. And the model is linearized by piecewise linearization. Finally, a modified IEEE33 node example is used to verify that the proposed model can improve the operation superiority of the system to a certain extent.

Keywords: Demand response, Uncertainty, Piecewise linearization, Optimization dispatch model.

Session [SS18] SS18: Invited Session on Advanced control technologies for robotic system and its applications

P1037

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.

P1123

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 realtime 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.

P1137

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.

P1212

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 of the robot's dynamics, and thus provides feasibility

in practice. Simulations and experiments on a 3-degrees-of-freedom (3-DoF) robot manipulator are carried out to demonstrate the effectiveness of the proposed approach.

P1225

Global Fast Terminal Sliding Mode Control for a Quadrotor UAV

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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.

Session [SS19] SS19: Invited Session on System Design and Test

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.

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.

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 practicability 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.

Session [SS20] SS20: Invited Session on Advanced Modeling, Analysis and Control Techniques and Emerging Applications of Modular Multilevel Converters

P1124

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

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Modular Multilevel Converters for HVDC 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-

facturing tolerance of digital controller crystal oscillators introduces controller clock inconsistency and finally leads to the asynchronism of triangular carriers implemented in individual SM for phase-shifted PWM scheme. Considering the tolerance of controllers having a normal distribution, the asynchronism of the triangular carriers is modelled based on the probability theory and the resulting switching harmonics are evaluated in this paper. The switching function model taking the asynchronism into account is proposed, in order to quantitively analyze the contents of switching harmonics around the low frequency and the equivalent switching frequency. The theoretical calculation of switching harmonics can be used to determine the optimal interval of the SM synchronization scheme according to the system THD requirement. The communication stress is largely eased because of the optimal synchronization scheme. The validity of the switching function model and the proposed optimal synchronization scheme are verified experimentally on a prototype of MMC.

Keywords: Modular Multilevel Converter (MMC), Submodule (SM) asynchronism, Synchronization scheme.

P1257

Method of Field Limiting Rings Spacing Parameter for SiC JBS Based on Multiple Linear Regression and Polynomial Fitting

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Power semiconductor devices designers often use Silvaco for device simulation. At present, when designing device field limiting rings(FLRs) terminal, it needs to fine tune the relevant parameters gradually for getting the expected results, which costs a lot of time. In order to solve this problem, this paper takes the SiC JBS as an example, the basic parameters of JBS field limiting ring structure for simulation are determined by formula derivation and simulation analysis. Taking the initial spacing s of field limiting ring S and the change step of field limiting ring spacing k as independent variables. The simulation data are divided into test groups and verification groups randomly, the test group data are brought into polynomial fitting and multiple linear regression combined model for training, and then the data of verification group are diagnosed. The results show that the model has a exceedingly superior prediction accuracy, which provides a great reference for designers to quickly get the structure parameters of the field limiting ring during the simulation in Silvaco, which saves a lot of simulation time.

Keywords: Field limiting rings, SiC JBS, Polynomial fitting, Multiple linear regression, Silvaco.

P1290

Minimal Capacitor Voltage Ripple Control for the Modular Multilevel Converter Based Wind Energy Conversion System

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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, whi0ch 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.

P1591

Multi-Stage Planning of Active Distribution Network Considering Correlation and Time Sequential Features

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This paper presents a multi-stage active distribution network (ADN) expansion planning model. The proposed model considers the phased construction of both the distributed power generations (DGs) and the feeders, and the correlation between DGs and loads in the same area. Correlation and time sequential feature samples are generated by Latin hypercube sampling (LHS) technique and the Cholesky decomposition technique, and scene models are generated by Kmeans method. The ADN investment model is an investmentoperation co-optimization one, which includes multi-stage distribution network planning at the

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 cooptimization 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.

P1280

FPGA-Based High-Frequency Pulse Power Supply for Micro Electroplating

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High-frequency pulse power supply with narrow pulse width plays a critical role for pulse plating in industry. The FPGA-based power supply introduced in this work can output multiple mode pulse waveforms including the unipolar group pulse and bipolar group pulse by means of controlling on-off of the MOSFETs. The minimum pulse width of single pulse waveforms is 4 μs. An example of Au film plating based on the power supply illustrates remarkable capabilities in many precious metals electroplating.

Keywords: Pulse power supply, Bipolar group pulse, High frequency, Au plating.

Session [SS21] SS21: Invited Session on System Simulation and Analysis

P1385

Formation Transforming Policy for Multi-agent System in Planetary Exploration

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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.

P1416

Modeling of Switched Reluctance Generator Based on Modelica

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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.

P1478

Data Analysis of Bitcoin Blockchain Network Nodes

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With the development of the world economy and network technology, the security and anonymity of the Bitcoin blockchain are increasingly valued by people. At the same

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 prospected.

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 trade-off has great effects on the design of hybrid mapping scheme. In this paper, we propose a model to analysis the write amplification trade-off in hybrid mapping scheme. Moreover, we redesign the greedy garbage collection and measure the performance differences between two algorithms in hybrid mapping scheme. Finally, we evaluate the design of write amplification trade-off based hybrid mapping Solid State Drives, and the algorithms proposed in this paper can resuce the write amplification factor and maintain the endurance at a high level.

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

P1266

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 fluxlinkage 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.

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.

P1576

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

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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 transi.

Session [SS22] SS22: Invited Session on Design for Electrical Components and Systems

P1351

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.

P1381

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.

P1502

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.

P1536

Design and Simulation of Large Flowrate Fuel Metering Valve of Aero engine Based on AMESim

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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 outputfeedback formation protocol is proposed based on leaderfollowing 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 proposed 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.

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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 closedloop 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.

P1609

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.

P1210

Progress of DC Quench Protection Switch for Superconducting Fusion Reactors

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The superconducting magnets are the most expensive and important components for a magnetic confinement thermonuclear fusion device. The high-intensity magnetic fields produced by high density DC current are used to confine and shape the high-temperature plasma in experiments. Therefore, the study of DC quench protection switches is extremely necessary and meaningful for the safety operation of superconducting magnets. Different types of switch have been studied based on various circuit requirements and parameters, such as interruption time, current and voltage. This paper reviewed the developing process of quench protection switch and summarized the respective characteristics of direct interruption commutation switch, artificial zero-crossing commutation switch and full-controlled active commutation switch. Finally, the paper expounded the recent development of three-level contacts hybrid DC breaker technology for next generation fusion reactor.

Keywords: Dc power transmission, Pulsed power technology, Power electronics, Plasma science.

P1025

A Reactive Component Elimination Method for Voltage and Current Stresses Analyses

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Traditional ways of applying ampere-second and volt-second 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.

Author Index

A

AL-Adhami, Marwah Saad Mahdi 69
Aalerud, Atle 29
Acharya, Parikshit 13
Ahiska, Kenan 29
Ai, Pinghua 31
Aimin, Zhang 66, 67
Al-Abri, Dawood 56
Al-Bulushi, Nooriya 56
Al-Maashri, Ahmed 56
Al-Saggaf, Yeslam 13
Alrashed, Bashair Ali 10
Amaratunga, Gehan A. J. 78
Aouf, Nabil 29
Aping, Wang 91
Arellanes, Alberto 39
Asl, Reza Mohammadi 18
Azmi, Tanzina Hassan 58

B

Bai, Junjie 13
Bai, Ying 6
Bai, Zhilong 88
Bailey, Chris 57
Balasubramanian, Sivagaminathan 26
Baliga, B. Jayant 35
Beferull-Lozano, Baltasar 49
Bhanu, P. Veda 10, 56
Bhatia, Jyoti 62
Bhattarai, Bimal 58
Bi, Cong 20
Bian, Shenyiyang 45
Bie, Zujie 53
Bjørnholm, Marius 52
Blaabjerg, Frede 101
Bo, Xingpeng 65
Bommes, Lukas 74

C

Cai, Wenjian 20, 19
Cai, Yi 90
Cao, Hong 38
Cao, Qixin 32
Cao, Yuan 73
Cao, Yuhao 78
Cao, Zhen 31
Cenkeramaddi, Linga Reddy 61, 62, 10 56
Chakrabarty, Amitabha 54
Chang, Che-Min 85
Chang, Che-Ming 86
Chang, Jiang 77
Chang, Tianji 61, 60,
Chang, Yuyang 23
Chen, Bin 29
Chen, C. L. Philip 76
Chen, Chenxia 54
Chen, Chuan 85
Chen, Gang 79, 96
Chen, Haiyu 95
Chen, Hao 58
Chen, J. K. 26
Chen, Jiawei 64
Chen, Ling 48
Chen, LingSen 12
Chen, Minwu 22, 23
Chen, Qi 92
Chen, Shih-Gang 17
Chen, Shuang 49, 51
Chen, Sitong 9
Chen, Tengpeng 78
Chen, Tian 68
Chen, Weidong 80
Chen, Weihai 85, 79, 83, 85, 33, 31, 79, 98, 80, 82, 81, 83
Chen, Wenjie 31, 79
Chen, Wu 34
Chen, Xi 72
Chen, Xiao 6
Chen, Xin 46
Chen, Xinyi 33
Chen, Xiongjun 92
Chen, Yidong 91
Chen, Yuanlong 27
Chen, Yue 71, 71
Chen, Zhenwei 81
Chen, Zhuoyuan 87, 86
Cheng, Min 98
Cheng, Peng 85
Cheng, Shu 70
Cheng, Yi 46
Cheng, Yilin 22, 23, 24
Cheng, Zhe 22, 23, 24
Chenxi, Huang 9
Choong, Weng Xian 5
Choux, Martin 30
Chu, Yingguang 75
Chua, Yansong 59
Chua, Yong Quan 73
Chuncheng-Han 38
Chunling, Yang 21
Claire, Jean-Claude Le 17
Crescitelli, Alberto Maximiliano 75

Cui, Can 19, 20
Cui, Shumei 47, 35
Cungang, Hu 40

D

Dai, Chaohua 22
Dai, Jing 94, 90, 88, 91, 91
Dai, Yunxiang 33
Datta, Ujjwal 16
Dena, Alejandro 29
Deng, Chunlan 98, 63
Deng, Fuming 43
Deng, Hanqiang 58
Deng, Lei 59
Deng, Qingli 48
Deng, Wenqi 71
Dharmadhikari, Bhushan 46
Dieng, Abdoulaye 17
Dinardo, Joseph E. 53
Ding, Dawen 98
Ding, Shichuan 98
Ding, Wenrui 81, 81
Ding, Yuemin 57
Diveev, Askhat 18, 61
Dong, Mi 25
Dong, Wenbin 52
Dong, Zhanlong 10
Dou, Wei 100
Dougherty, Mark 7
Doumiati, Moustapha 22
Du, Chaofan 65
Du, JiaLu 59
Du, Yudong 67
Du, Yun 22
Duan, Minghua 98, 98
Duan, Pinggang 57
Duan, Wen 80
Duo, Zhao 9
Dybedal, Joacim 51
Dybedale, Joacim 76

E

Erdogan, Dennis 3
Ewald, Robert 18

F

Fan, Jianyin 29
Fan, Kuangang 60
Fan, Yanli 68
Fan, Yinlong 63
Fan, Zhang 97, 5, 11
Fang, Fang 6, 32,
Fang, Lingqi 25, 26, 44
Fang, Zaojun 79, 79
Farbiz, Farzam 58
Fekih, Afef 18
Feng, Gang 20
Feng, Guodong 66
Feng, Rongwei 12, 55
Feng, Wendong 44
Feng, Z. C. 26, 53
Fleyeh, Hasan 10
Fu, Peng 100
Fu, Xiuju 78
Fu, Yingzhuo 79
Fung, Pak L. 14

G

Gan, Wen 64, 63,
Gansel, Lars Christian 75
Gao, Bo 62
Gao, Feng 56
Gao, Jiayue 27
Gao, Shibin 72
Gao, Xiaoshan 86
Gao, Zhanbao 91
Garcia, Cristian 66
Ge, Jianjun 82
Ge, Xinglai 95, 73, 97, 72
Ge, Xingli 48
Gerada, Chris 86
Gerada, Christopher 16
Gong, Xin 31
Goodwin, Morten 58
Govil, Vibhor 56
Grandhi, Lakshmi 9
Grandhi, Srimannarayana 9
Granmo, Ole-Christoffer 58
Gravdal, Jan Einar 18
Gu, Haibo 68
Gu, Linsong 84
Gu, Nanhao 99
Gu, Yan Zhang 23
Guan, Yue 3
Guo, Chaoyong 88
Guo, Chujian 55
Guo, Fang 93
Guo, Fanghong 85, 64
Guo, Jiamin 52
Guo, Jing 52, 52
Guo, Qi 89
Guo, Qiuting 25, 44
Guo, Weisheng 34
Guo, Xiaofeng 98
Guo, Yangming 14, 12
Guo, Yi 63
Guo, Yudi 28
Guo, Zhen 31
Guo, Zhengjin 5

H

Hagen, Daniel 30
Hagh, Yashar Shabbouei 18

Hai, Marcus Koh Leong 66
Hametner, Christoph 3
Han, Danyang 94, 90
Han, Li Qun 23
Han, LiQun 26
Han, Pengcheng 72
Han, Pingping 62
Han, Pinpin 62
Han, Qi 21
Han, Wenye 17, 16
Han, X. Q. 23
Han, Xiaoqing 38
Han, Yitong 89
Han, Yuqi 96
Han, Zhangang 79
Handroos, Heikki 18
Hang, Jie 99
Hang, Zhang 66
Haobang, Xu 91
Haoguang, Li 51, 54
Haoran, Liu 70
Hasan, Mahmudul 58
Hassan, Syed Zafrul 58
Hassw, Kevin 55
He, Bing 60
He, Bolong 53
He, Guoqing 43
He, Hongwen 77
He, Jun 12, 26
He, Mingyi 8
He, Rui 4
He, Xiao 67
He, Xiaoqiong 72
He, Xintian 43
He, Zhihao 48
He, Zhuang 86
Heng, Xidan 8, 28
Herrera, Ana Elsa Hinojosa 57
Hildre, Hans Petter 76
Hong, Jihoon 74
HongZhu 23
Hongliang, Mao 11
Hou, Yishuang 96
Hovland, Geir 62, 29, 76, 51, 76, 61, 30
Hsu, Bo-Yuan 86
Hu, Bo 47
Hu, Baizhong 53
Hu, Cungang 40
Hu, Huizhong 19
Hu, Jibin 77
Hu, Jieyu 28
Hu, Pengfei 25
Hu, Wei 25
Hu, Wenmin 21, 28,
Hu, Xiao 97, 72,
Hu, Xiaoguang 84, 85, 94, 83, 84, 97
Hu Xiaoguang 84
Hu, Xingguang 100
Hu, Y. H. 41
Hua, Y. C. 41
Huaibing, Li 91
Huan-He 38
Huang, Bin 85
Huang, Hongyang 64
Huang, Jangshuai 69
Huang, Jian 58
Huang, Jihua 64, 63,
Huang, Jingchun 72, 71,
Huang, Jingjing 65, 67, 66, 66
Huang, Lili 6
Huang, Weihua 19
Huang, Wen Tao 23
Hung, Chun-Chen 86
Huo, Qiantao 87
Hussain, Emtiaz 58
Hussain, Walayat 10
Hussein, Oubai 61
Husseinz, Tareq 14

I

Ilen, Elina 15

J

J, Soumya 10, 56
J., Soumya 62
Jagadeesh, Samala 56
Jakubek, Stefan 3
Jha, Ajit 62, 61, 62, 48
Ji, Yuhan 79
Ji, Zhengping 27
Jia, Qingxuan 96
Jia, Y. B. 23
Jia, Yihang 39, 41
Jian, Wang 83
Jiang, Chaoyang 77
Jiang, Daozhuo 25
Jiang, Haoge 32
Jiang, Lili 51
Jiang, Nannan 63
Jiang, Qilong 71, 8, 71, 28, 27, 8
Jiang, Wenjun 32
Jiang, Yiming 93, 92
Jiang, Zheng 19
Jiang, Zhiyu 52
Jiao, Lei 58
Jiao, Peng 59
Jin, Cheng 43
Jin, Hai 46
Jin, Jing 29
Jin, Mingbo 73
Jin, Ningyuan 8
Jin, Qiming 6
Jin, Shangzhu 13
Jin, Yinli 87, 80,
Jing, Haitao 89, 88,
Jing, Qi 47

Jingjing, Huang 66
Jinglin, Yang 97
Jomaa, Diala 7
Juang, Chia-Feng 85
Jun, Shen 95
JunWang 21
Junde-Liu 38

K

Kalam, Akhtar 16
Kaldestad, Knut Berg 30
Kamal, MD Rasheeq Ishraq 54
Kanale, Ajit 35
Kauranen, Ilkka 15
Ke, Deping 37
Ketai, He 11, 11, 97,
Khan, Rafia Tabassum 54
Kim, Sangtae 26
Kodagoda, Sarath 53, 13, 4, 60
Koh, Leong Hai 65
Kong, Lingkun 85
Kong, Qian 36, 39, 36,
Kristensen, Terje Solsvik 59
Kulmala, Markku 14

L

Løvsland, Per-Ove 61
Lagerspetz, Eemil 3
Lai, Xiaoyu 96
Lan, Cuiqin 56
Landsverk, Ronny 76
Lang, Bin 44
Lang, Yanshu 16, 17
Lares, Josue Alvarez 54
Le, Hai Xuan 30
Lee, Hong-Hee 36
Lee, Kee Jin 74
Lei, Ma 70
Lei, Mingyu 100
Lei, Xiangbing 92
Lei, Yuanyuan 41
Lei, Zhang 67, 66
Li, Bin 26, 16, 12
Li, ChenXi 8
Li, Chuan 100
Li, Fan 64
Li, Fei 45
Li, Geng 14, 66,
Li, Guoli 46
Li, Guoyuan 75, 76, 75
Li, Haiyan 88
Li, Hua 100
Li, Huixuan 28
Li, Jiangang 93
Li, Jianyuan 47
Li, Jiangrong 16
Li, Jie 29
Li, Ke 27, 27,
Li, Ke-Jun 96
Li, Lanpu 79
Li, Lei 42, 42, 42, 42, 3, 43
Li, Li 84
Li, Ming 40
Li, Mingxia 17
Li, Qiang 72
Li, Ruihai 33
Li, Shuting 50, 71, 50
Li, Tianfu 99
Li, Tianlong 33
Li, Tieshan 16, 76
Li, Wei 98, 55,
Li, Weining 89
Li, Wenyi 27
Li, Xiang 74, 74, 20
Li, Xianshan 12
Li, Xiaohui 57
Li, Xinyang 14
Li, Ya 44, 25, 26
Li, Yanan 93
Li, Yang 33, 83
Li, Yangyang 99
Li, Yongming 68
Li, Youguang 40
Li, Yuan 12
Li, Yuze 81
Li, Yuhao 101
Li, Yunhua 46, 99, 85
Li, Yurong 93
Li, Yuxin 43
Li, Zhengguo 81
Li, Zhengtian 84, 85
Li, Zhenwei 27, 28
Li, Zhi 62
Li, Zhuoxin 70
Li, Zizhan 71
Lia, Guoqi 59
Liang, Chia-Hui 17
Liang, D. K. 23
Liang, Fen 71, 71,
Liang, Jiayi 22
Liang, Qingmin 60, 61
Liang, Xiao 87
Liao, Huanian 49
Liao, Jianquan 47
Liao, Kai 24
Liao, Zirui 86
Lii, JinHu 68
Lim, Keng Pang 10
Lin, Chengqian 64, 63
Lin, Chun-Liang 85, 86
Lin, Faa-Jeng 17
Lin, Jianheng 100
Lin, Peng 70
Lin, Xinlin 74
Ling, Feng 35
Ling, Nam 10

Liu, Ao 88
Liu, Beibei 26, 25, 44
Liu, Bin 19, 19
Liu, Chuang 46
Liu, Dong 8, 8, 50, 28, 27, 50, 28, 95
Liu, Enmao 6, 5, 56
Liu, Fang 45
Liu, Fuhuang 91
Liu, Guanghong 82
Liu, Guangmin 96, 47
Liu, Haichun 38
Liu, Hansen 60
Liu, Haochen 90
Liu, Hong 9, 53,
Liu, Hongpeng 65, 101
Liu, Jiaqi 92
Liu, Jieying 96
Liu, Jingmeng 98, 83
Liu, Jingwei 80
Liu, Kexin 68
Liu, Lei 84, 97, 84, 94
Liu, Lijuan 6
Liu, Lu 83, 20,
Liu, Quan 58
Liu, Ruofei 23
Liu, Shiquan 45
Liu, Shu 21
Liu, Shun 95
Liu, Xiangbin 21, 92
Liu, Xiaoxi 40
Liu, Xuna 96
Liu, Yajun 44
Liu, Yang 45, 27, 8
Liu, Ying 10
Liu, Yonglu 100, 100
Liu, Yuanli 22, 24
Liu, Yue 25, 41, 39
Liu, Yujia 72
Liu, Zhangjie 20
Liu, Zhenxing 57
Liu, Zhijie 96
Liu, Zhitao 69, 69
Liu, Zhou 11
Liu, ZiSen 43
Liu, Ziyang 81
Loh, Poh Chiang 101
Long, Chuan 96
Long, Jiang 69, 69
Lou, Boliang 64
Lozano, Baltasar 61
Lu, Fan 28, 27, 28
Lu, Ling 61
Lu, Nan 12
Lu, Wen Feng 74
Lu, Xiao 87
Lu, Yang 4
Luo, JunPing 12, 26
Luo, Lele 49
Luo, Shucong 4
Luo, Wei 94, 87,
Lv, Ning 51, 51, 49
Lv, Quanxu 25, 26, 44
Lyu, Chao 89, 89, 88, 89

M

Ma, Baozhao 89
Ma, Cheng 59
Ma, Chuang 6
Ma, Dazhong 11
Ma, Dongying 84
Ma, Hongxu 30
Ma, Jinhui 62
Ma, Junchao 64
Ma, Lin 82
Ma, Mingyao 45, 34, 35
Ma, Ran 27
Ma, Teli 82
Ma, Xiang 30
Ma, Xiaochen 46
Ma, Xiaoyu 91
Ma, Xin 27
Ma, Xudong 32, 20, 6
Ma, Yuzhuo 76
Ma, Zhenwei 67
Mandapati, Nikita 10
Mao, Jiandong 31
Matsumi, Yutaka 14
Meng, Na 34
Meng, Runquan 38
Meng, XiaoLi 43
Meng, Xuesong 35
Miao, Cunjian 55
Miaolong, Yuan 58
Mohajeri, Babak 14, 15
Moi, Sonja 18
Molinas, Marta 35
Mora, Dante 39
Morel, Cristina 22
Motlagh, Naser Hossein 14, 3
Mu, Huaiyi 90
Muhammad, Amir 51
Myo, Kyaw Sett 5

N

Nøland, Jonas Kristiansen 35
Núñez, Ciro 39
Nam, Seungwan 24
Nan, Zhang 5
Nelson, Mark 15
Nestorović, Tamara 55
Nguyen, Linh 30
Nguyen, QuangDuy 16
Ni, Jun 77
Ni, Yue 88, 91
Nilssen, Markus Sauer 59
Ning, Guangfu 34

Ning, Jun 16
Niu, Jianwei 6
Niu, Lulu 14
Niu, Wenqi 31
Nurmi, Petteri 3
Nyberg, Roger G. 7
Nyberg, Timo 15
Nyberg, Timo R. 14

O

Olivier, Jean-Christophe 22
Ou, Zhixin 98
Ould-Khaoua, Mohamed 56
Oveisi, Atta 55

P

Padovani, Damiano 29
Paek, Sung Wook 26
Pai, P. Frank 53
Pan, Lizhu 62
Pan, Wei 62
Pan, Xiaobo 39
PanYan 54
Pang, Shaoning 13
Pang, Tao 52, 52
Park, Daeseong 24, 36
Parvez, Mohammad Zavid 58, 54
Patel, Sarosh 31
Patel, Sarosh H 46
Pei, Jing 59
Pei, Shuiqiang 85, 84,
Pei, Yangzhou 37
Pei, Zhongcai 33, 80, 93,
Peng, Jun 13
Peng, Liu 91
Peng, Yan 64
Peng, Yusheng 72
Peng, Zongju 81
Petäjä, Tuukka 14
Pham, Minh Duc 36
Piyathilaka, Lasitha 13
Prasad, Mukesh 4

Q

Qian, Hao 37, 45
Qian, Zhe 46
Qichao, Tang 9
Qin, Wenping 38
Qin, Yao 7
Qin, Yi 93
Qingqiang, Hu 11
Qiu, Rujia 62
Qu, Jianzhen 35, 47
Qu, Pingping 52, 52

R

Rahman, Md Anisur 13, 58
Ramos, Luis Miguel Lopez 49
Rebeiro-Hargrave, Andrew 3
Rebreyend, Pascal 7
Remøy, Knut 75
Ren, C. G. 23
Ren, Qinyuan 33
Ren, Zhengru 52
Rodriguez, Jose 66
Royo, Santiago 48

S

Saadallah, Nejm 18
Saeed, Mahmoud S. R. 70
Saeed, Nausheen 7
Salem, Mohamed E. M. 30
Saleque, Shahriar 54
Sha, Deshang 40
Shang, Chao 12
Shao, Yurun 12
Shen, Chengliang 64, 63
Shen, Lu 94
Shen, Tielong 15
Shen, Wen 43, 44
Shen, Xiaorong 51
Sheng, Jian 5
Sheng, Yi 89
Shenwen, Lin 97, 11
Shi, Fangli 22
Shi, Jian 88
Shi, Juan 16
Shi, Shuo 88
Shmalko, Elizaveta 18
Shor, Roman 18
Shu, Zeliang 72
Shumsky, Alexey 18
Skjetne, Roger 36
Sobh, Tarek 31, 46
Sohagh, Khan Shahnewaz 38
Song, Bao 15
Song, Boyang 83
Song, Dongran 25, 26
Song, Shuangcheng 48
Song, Wenbin 20
Song, Wensheng 70, 4
Song, Xiao 93, 83,
Song, Yankong 89
Song, Yuanshang 52
Song, Zhiquan 100
Soumaoro, Ousmane 22
Spriha, Gul-A-Zannat 54
Su, Hang 95
Su, Hongye 69, 69
Su, Mei 100, 100
Su, Qiying 80
Subedi, Dipendra 62, 61

Sui, Dan 18
Sukhairi, T. Arriessa 55
Sun, Caimiao 52
Sun, Cuiqing 100
Sun, GuangHui 12
Sun, Jian 55
Sun, Lu 78
Sun, Pengfei 72
Sun, Qiuye 11
Sun, Shujie 16, 17
Sun, Weixin 72, 97
Sun, Xiantao 79, 83
Sun, Yajuan 74
Sun, Yao 100, 100
Sun, Yi 84
Sun, Yue 40
Sun, Yuhao 78

T

Tai, Yu 41, 39
Tang, Cunwen 100
Tang, Dedong 13
Tang, Diyin 91, 94, 90
Tang, Huaguo 92
Tang, Maosen 95
Tang, Ming 63
Tang, Ting 90
Tang, Xiaoqi 15
Tang, Zhiyong 80, 93
Tang, Zhiyuan 51, 49, 51
Tao, Xingyu 21
Tao, Yibin 34
Tarkoma, Sasu 14, 3
Thiyagarajan, Karthick 4, 30, 60, 53, 13
Tian, Hanqing 77
Tian, Limei 91, 94, 90
Tian, Yanfu 14
Tian, Yichao 45
Tian, Yu-Chu 68
Tong, Wei 63, 64
Tong, Xiangqian 65, 66
Tongyiyu, Zhang 21
Traoré, Bakou 22
Tu, Yingzhe 51
Tu, Zhenwei 50
Tyapin, Ilya 62, 61

U

Ulapane, Nalika 53, 4, 60

V

Varjonen, Samu 3
Vasundhara, Jayaraman 78
Venna, Trinadh V S N 31
Verma, Amrit Shankar 52
Visairo-Cruz, Nancy 39
Vishkarma, Santosh Kumar 62

W

Walshaw, Chris 57
Wan, Chengzhi 42, 42
Wan, Kong-Wah 32
Wang, Benfei 66
Wang, Bingyu 11
Wang, Chang 63, 58
Wang, Cheng 94
Wang, Dali 6
Wang, Ershen 52, 52
Wang, Fujie 93
Wang, Fusheng 35
Wang, Gaolin 44, 43
Wang, Haixia 87
Wang, Haiyang 27
Wang, Haiyu 95
Wang, Han 32
Wang, Haodong 45
Wang, Haoran 88, 90
Wang, Hongyan 31
Wang, Hongyu 81, 81
Wang, Hui 84
Wang, Huijun 51, 49, 51
Wang, Jiahua 33
Wang, Jian 25, 44
Wang, Jianhua 83, 85, 31, 81, 43, 82, 80
Wang, Jinyu 96
Wang, Jun 90, 80, 87
Wang, Junwu 6
Wang, Kangjun 92
Wang, L. 23
Wang, Lei 63, 69, 63, 69, 38, 64
Wang, Li 97
Wang, Linna 94
Wang, Lupan 27
Wang, Meng 45
Wang, Na 87
Wang, Pengfei 32
Wang, Ping 87, 80
Wang, Qiang 30, 29
Wang, Qianggang 47, 19
Wang, Qing 96, 54
Wang, Qingyuan 72
Wang, Qunjin 98
Wang, Qunjing 46
Wang, Ruiquan 96
Wang, Runqi 82
Wang, Saisai 87
Wang, Shaojie 84
Wang, Shaoping 88, 87, 99, 86
Wang, Shiqin 49, 50
Wang, Shuai 21, 90
Wang, Shuo 83
Wang, Song 72
Wang, Tao 56
Wang, Wei 82, 49, 69, 69

Wang, Xi 62
Wang, Xiaodong 14, 12
Wang, Xiaofeng 50
Wang, Xiaoyu 63
Wang, Xiaozhong 64
Wang, Xingjian 21, 90, 99
Wang, Yao 28, 48
Wang, YiYang 28
Wang, Yibo 100
Wang, Yifan 79
Wang, Yiyang 8
Wang, Yu 73
Wang, Yue 60
Wang, Yujiao 85
Wang, Yunlong 25, 44
Wang, Yuxin 54
Wang, ZhiGuang 59
Wang, Zhuqing 14, 12
Wei, Chao 77
Wei, Gang 88
Wei, Heng 7
Wei, Jiaxin 39, 36, 36
Wei, Jun 96
Wei, Junhong 101
Wei, Muheng 67
Wei, Ruoyu 50, 50
Wei, Zhang 66, 67
Wei, Zhongbao 77, 78
Wen, Changyun 64, 68
Wen, Jiakun 73
Wen, Zhaoliang 88
Weng, Qiwang 88
Wensheng, Song 70
Wibowo, Santoso 9
Wong, Wilfred Kang Chee 5
Wu, Baiheng 76, 75
Wu, Hongfei 41, 39
Wu, Jiaxing 4
Wu, Qi 88
Wu, Shaopeng 33
Wu, Shiqian 57, 4, 29,
Wu, Songrong 28, 36, 71, 50, 50, 36, 39
Wu, Xingming 85, 85, 82, 81
Wu, Xueying 77
Wu, Yao 91
Wu, Yue 16
Wu, Zheng Rong 23

X

Xi, He 11
Xia, Jing 34
Xia, Yitong 94
XiaYing, Zhang 9
Xiang, Chaoqun 70
Xiang, Shiqiang 71
Xiang, Yueping 28
Xiang, Yujie 9
Xiao, Jianfang 66, 65
Xiao, Jin 83, 84, 97, 84, 94
Xiao, Longhai 46, 92
Xiao, Ming 69
Xiao, Xiulin 63
Xiao, Yao 63
Xiao, Yu. 23
Xiaomeng, Jiang 97
Xie, Hengyu 80
Xie, Hong 24
Xie, Le 8
Xie, Shaojun 37, 38, 45
Xie, Shiming 100
Xie, Shoulie 4
Xie, Yuanlong 15
Xie, Zhen 23
Xin, Qingmin 41
Xing, Lantao 68
Xing, Yan 41, 39
Xing, Zhuoyi 77
XinhuaZhang 21
Xiong, Gang 15
Xiong, Guangyu 14
Xiong, Guansong 21, 90
Xiong, Xiaobin 53
Xu, Bowen 64
Xu, Chenyang 79
Xu, Chunbi 9
Xu, Dianguo 43, 44
Xu, Hai-Yan 78
Xu, Jian 37
Xu, Jiazhu 34, 41
Xu, Jinming 45, 37
Xu, Lei 87
Xu, LiangPeng 43
Xu, Limei 28, 48
Xu, Rui 50
Xu, Siqing 37
Xu, Song 52
Xu, Wangming 57
Xu, Xiang 20
Xu, XiangYang 100
Xu, Xin 49
Xu, Xinyu 39
Xu, Yangjun 24
Xu, Zhao 97
Xu, Zhengqin 4
Xue, Zhongbing 34

Y

Yadav, Rohan Kumar 58
Yan, Hongmei 8
Yan, Liang 16, 86
Yan, Longhao 80
Yan, Pang 51
Yan, Ruitao 37
Yan, Shenglai 89
Yan, Z. 41
Yang, Bo 85, 91, 99,

Yang, Chengbo 15
Yang, Chenguang 93, 92
Yang, Chunling 88, 12, 55, 97, 81
Yang, Guilin 83
Yang, He 51
Yang, Huan 12, 14
Yang, Jian 26, 44
Yang, Jianbing 93
Yang, Jianwei 24
Yang, Junyao 8
Yang, Liman 46, 99
Yang, Liu 39
Yang, Meihui 19
Yang, Ping 36, 36, 72
Yang, Shunfeng 96, 95
Yang, Shuying 34
Yang, Tingting 68
Yang, Wu 61, 60, 13
Yang, Yang 68
Yang, Yaqian 34
Yang, Yifan 25
Yang, Yukuan 59
Yang, Zewen 49, 51, 51
Yang, Zhentao 22
Yang-Cao 38
Yao, Cheng 6
Yao, Hongjing 14
Yao, Weifeng 71, 71
Yapp, Edward Kien Yee 74
Yau, Wei-Yun 32
Ye, Haifeng 62
Ye, Shengyong 96
Yeow, John T. W. 93
Yi, Sheng 12
Yin, Xiao Feng 78
Ying, Fangtian 6
Yu, Bin 70
Yu, D. S. 41
Yu, Dong 16, 17
Yu, Honghai 89
Yu, Jialin 92, 46
Yu, Jianlin 74
Yu, Jinsong 91, 94, 90
Yu, Shimin 33
Yu, Yang 67
Yu, Yifan 35
Yu, Zhibin 54
Yu, Zhou 58
Yuan, Hui-Mei 90
Yuan, Li 51, 49, 51
Yuan, Liang'en 76
Yuan, Lu Lu 23
Yuan, LuLu 26
Yuan, Weiran 47
Yuan, Lulu 91
Yuan, Xin 50
Yuan, Xue 47
Yuan, Yangyang 19
Yuan, Yongtao 65
Yudong, Du 66
Yue, Haosong 82, 81, 85, 90
Yue, Sun 40
Yun-Hua, Li 83
Yunhong, Zhou 66
Yunlei, Zhang 40

Z

Zadeh, Mehdi Karbalaye 36, 24
Zaidan, Martha Arbayani 14
Zaman, Bakht 49
Zhai, Deqing 78
Zhai, Jiankun 77
Zhai, Lili 71, 71
Zhan, Taoning 8
Zhan, Xin 34
Zhang, Bai 31
Zhang, Baochang 81, 82, 81, 94
Zhang, Chao 86, 87
Zhang, Chenghui 27, 27
Zhang, Chuanlin 63
Zhang, Cong 6
Zhang, De 82
Zhang, Debin 40
Zhang, Dongxia 38
Zhang, Du 13
Zhang, Duona 81, 81
Zhang, Fan 56, 10
Zhang, Fangpei 82
Zhang, Feihu 36
Zhang, Gongping 21
Zhang, Guofeng 97, 83, 94, 84
Zhang, Guoliang 82
Zhang, Guoqiang 43, 44
Zhang, Hang 67
Zhang, Hanshuang 8
Zhang, He 77
Zhang, Hongpeng 44
Zhang, Hongying 88
Zhang, Houxiang 76, 75, 75, 76, 75
Zhang, Hui 98
Zhang, Jianbin 79, 31, 83, 79, 80
Zhang, Jinchuan 3, 42, 42
Zhang, Jingliang 55
Zhang, Jinqing 82
Zhang, Jiuzhu 34
Zhang, Jun 24
Zhang, Ke 34
Zhang, Lei 65
Zhang, Lin 96, 47
Zhang, Liqin 16
Zhang, Liusheng 40, 23
Zhang, Liuyang 48
Zhang, Liwen 94
Zhang, Lu 51
Zhang, Lulin 70
Zhang, Nan 62
Zhang, Peng 98

Zhang, Pengyu 87, 86
Zhang, Pinjia 35
Zhang, Qi 19
Zhang, Qianfan 48, 35, 47
Zhang, Qin 57, 22
Zhang, Qinghua 71
Zhang, Qiyan 87
Zhang, Ruixuan 19
Zhang, Shanlu 42
Zhang, Shuang 89
Zhang, Ting 77
Zhang, Wanbing 78
Zhang, Wei 6, 65, 65, 66
Zhang, Wen-An 64
Zhang, Wentao 96
Zhang, Xi 48
Zhang, Xin 19, 42, 42, 20
Zhang, Xinan 70
Zhang, Xing 40, 34, 45
Zhang, Xinhua 90
Zhang, Xueyan 53
Zhang, Yan 21, 12, 81
Zhang, Yanqun 46
Zhang, Yaolei 91
Zhang, Ye 53
Zhang, Yi 44
Zhang, Yichen 53
Zhang, Yifei 68
Zhang, Yongbin 96, 47
Zhang, Yongxin 45
Zhang, Yukexin 91
Zhang, Yunfei 43
Zhang, Yuwei 99
Zhang, Yuwen 26
Zhang, Zhao 67
Zhang, Zhe 45
Zhang, Zhenbin 35
Zhang, Zhendong 21
Zhang, Zhengkai 62
Zhang, Zhengqiang 67
Zhang, Zhi 8, 7, 5, 7
Zhang, Zijun 21, 90
Zhao, Boyang 85
Zhao, Changchen 86
Zhao, Chongjuan 63
Zhao, Danxu 21
Zhao, Fengda 12
Zhao, Haibo 73
Zhao, Hu 31
Zhao, Ji Guang 23
Zhao, JiGuang 26
Zhao, Jianfeng 43
Zhao, Kai 15
Zhao, Linjie 41, 33
Zhao, Luman 76, 75
Zhao, Nannan 43
Zhao, Xinfeng 89
Zhao, Yanben 89
Zhao, Yang 77, 77
Zhao, Zheng 33, 80
Zhao, Zhiqiang 98
Zhao, Zhiyang 25
Zheng, Changbao 44
Zheng, Feng 32
Zheng, Shifeng 55
Zheng, Shunwei 24
Zheng, Tianlun 50
Zheng, Yating 79
Zheng, Yingjie 50, 50
Zheng, Yongle 28
Zheng, Zewei 68
Zhenyu-Shi 38
Zhirabok, Alexey 18
Zhong, Ganggang 93
Zhong, Hongliang 40
Zhong, Ming 4
Zhou, Bo 6
Zhou, Cheng 37, 44
Zhou, Chunyan 31
Zhou, Dan 64, 63
Zhou, Hangrui 55
Zhou, Jian 46
Zhou, Jie 34, 41
Zhou, Jiehan 14
Zhou, Jing 69, 76
Zhou, Jingsong 63
Zhou, Junhong 74, 74, 73
Zhou, Niancheng 47, 19
Zhou, Qiang 59
Zhou, Qing 83
Zhou, Rongbin 95
Zhou, Shenling 85
Zhou, Yang 36, 39, 36
Zhou, Yulan 100

Zhou, Yunhong 67
Zhou, Zhengdong 95
Zhou, Zichao 101
Zhu, Chengzhi 93
Zhu, Guoliang 68
Zhu, Hong 40, 39
Zhu, Jiahao 65
Zhu, Jun 90
Zhu, Junlin 33
Zhu, Min 88, 97, 12
Zhu, Ming 68
Zhu, Naixuan 25
Zhu, Qianlong 63
Zhu, Shihuai 89
Zhu, Shunjie 77
Zhu, Wenxin 33
Zhu, Zhiwei 94
Zhuang, Jing 74
Zhang, Jiantong 52
Zhang, Lu 49, 51
Zhuang, Wenxiu 69
Zia, Tanveer 13
Zou, Bihai 9
Zou, Jun 41
Zou, Rui 9
Zou, Yu 9
Zou, Zhiyu 12
Zuev, Alexander 18