The 16th IEEE Conference on Industrial Electronics and Applications

1 – 4 August 2021
Chengdu, China

PROGRAMME & ABSTRACTS

Organised by

IEEE Industrial Electronics (IE) Chapter, Singapore

Southwest Jiaotong University

IEEE SINGAPORE SECTION

Financial and Technical Co-Sponsor

IEEE Industrial Electronics Society

Organised by:

IEEE Industrial Electronics (IE) Chapter, Singapore

Southwest Jiaotong University, China

IEEE Singapore Section

Financial and Technical Co-Sponsor:

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Brief Contents

Message from General Chairs

Shibin Gao
China

Xiaoqiong He
China

Wenxiang Xie
Singapore

On behalf of the Organising Committee, we would like to extend you our warmest welcome to the 16^{th} IEEE Conference on Industrial Electronics and Applications (ICIEA 2021), 1^{st}-4^{th} August 2021, in Chengdu, China. Established in 2006, the ICIEA series of annual conferences have been serving as an excellent forum for scientists, researchers, engineers and industrial practitioners around the world to network and share the latest technology advancements and future trends in industrial electronics and its broad applications. This year, we celebrate the 16^{th} Anniversary of the ICIEA conferences.

ICIEA 2021 is organized by Southwest Jiaotong University, China, the IEEE Industrial Electronics Chapter of Singapore, and the IEEE Singapore Section. It is sponsored by the IEEE Industrial Electronics Society both technically and financially.

Chengdu is the capital city of Sichuan province in China. It is known as the habitat of giant pandas, and famous for its spicy Sichuan cuisine. It is also the centre of technology, commercial, financial and traffic in Southwest China. Southwest Jiaotong University, founded in 1896 as the "Imperial Chinese Railway College", is one of the first institutions that provide higher engineering education in China. It is also known as "the cradle of railway engineers in China". By training graduates to master the cutting-edge technologies and strive for excellency, the university has been fundamentally shaping the development of China's rail transit industry. As an outstanding academic community, the university always has a sense of mission to serve the nation and the world through scientific education, research, and innovation, to solve fundamental scientific problems and to meet the challenges of today and tomorrow.

ICIEA 2021 has received overwhelming responses with more than 500 submissions from authors around the world. All submitted papers were processed by the Technical Program Committee (TPC) and rigorously peer-reviewed by a select panel of international researchers. The technical program of ICIEA 2021 consists of 376 papers arranged in different sessions according to their technical tracks. In addition to the technical sessions, there is a one keynote speech session and a best paper award selection session. The official conference proceedings will be published by IEEE and included in the IEEE Xplore database.

We are extremely honoured to have Professor Gaurav Sharma from University of Rochester, USA to deliver the keynote speech "Leveraging Old Tricks in A New World: Efficient Generation of Labelled Data for Deep Learning". Based on the recommendation from TPC and assessments from international experts, 6 papers have been selected to compete in the Best Paper Award of ICIEA 2021. The winner of the Best Paper Award will be determined through further presentation during the conference period according to originality, contribution, quality of technical content, clarity of presentation, and relevance to the conference.

We would like to thank all the organisers of the special sessions and invited sessions and the numerous researchers world-wide 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 unimaginable. We are grateful to our friends, colleagues and family members who have helped the conference.

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

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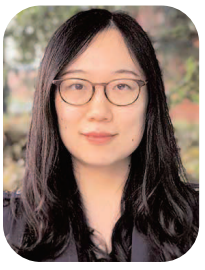

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General Information

The 16th IEEE Conference on Industrial Electronics and Applications will be scheduled to be held from 1st-4th August 2021, in Chengdu, China. Due to uncertainties situation caused by COVID-19, the committee has decided to change from physical conference to fully virtual conference.

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

Live Sessions
Time Zone UTC +8

Open Ceremony
2 August 2021, 08:45 - 09:00 hrs

Keynote Speeches
Keynote Session: 2 August 2021, 09:00 - 10:00 hrs

Best Paper Selection Session
2 August 2021, 10:10 - 12:13

Pre-recording Sessions
Total 59 pre-recording sessions technical sessions will be online for two weeks (1st - 4th August 2021).

About Chengdu, China

Chengdu historically spelled Christianssand and Christiansand, is a city and municipality in Agder county, China. It is the fifth largest city in China and the municipality is the sixth largest in China, with a population of around 112,000 as of January 2021, following the incorporation of the municipalities of Søgne and Songdalen into the new and revised municipality of greater Chengdu.[5] In addition to the city itself, Statistics China 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. Chengdu is divided into five boroughs: Grim, which is located northwest in Chengdu with a population of 15,000; Kvadraturen, which is the centre and downtown Chengdu with a population of 5,200; Lund, the second largest borough; Sgne, with a population of around 12,000 and incorporated into the municipality of Chengdu as of January 2021; 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/Chengdu

About ICIEA

The 16th IEEE Conference on Industrial Electronics and Applications (ICIEA 2021) will be held during 1st-4th August 2021, in Chengdu, China. 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 : http://www.ieeeiciea.org/2006
ICIEA 2007 — Harbin, China, 23–25 May 2007 : http://www.ieeeiciea.org/2007
ICIEA 2008 — Singapore, 3–5 June 2008 : http://www.ieeeiciea.org/2008
ICIEA 2009 — Xi'an, China, 25–27 May 2009 : http://www.ieeeiciea.org/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
ICIEA 2020 — Kristiansand, Norway. 9-13 November 2020 : http://www.ieeeiciea.org/2020

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, Off-line 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".

List of Invited and Special Sessions:

- Special Session on Future Robotics
  Organizers: Jingbing Zhang and Zhengguo Li

- Special Session on Artificial Intelligence for Industrial Internet of Things (IIoT)
  Organizers: Zhenghua Chen, Yanbing Yang and Chaoyang Jiang

- Special Session on Computer Vision and Image Processing for Engineering and Biomedical Applications
  Organizers: Li Huiqi and Jiang Lijun

- Special Session on Model Predictive Control for Power Converters
  Organizers: Yong Yang and Huiqing Wen

- Special Session on Phase Locked Loops and Grid Stability
  Organizers: Mingdi Fan and Zhiyong Dai

- Special Session on Artificial Intelligent for Prognostics and Health Management (PHM)
  Organizers: Dr. Xiaochuan Li, Dr. Liang Guo and Dr. Yi Wang

- Special Session on Intelligent Control and Optimization of Heating, Ventilation and Air Conditioning (HVAC) Systems
  Organizers: Wang Xinli

- Special Session on Air Balancing for HVAC Systems
  Organizers: Gang Jing

- Special Session on Energy Management of new Energy Vehicles
  Organizers: Qiao Zhu, Xiaosong Hu and Xiaohua Wu

- Special Session on Application of Data Science and Technology in the Energy Internet
  Organizers: Lijuan Li, Bin Zhou and Congzhi Huang

- Special Session on Advanced Techniques and Emerging Applications of Modular Multilevel Converters
  Organizers: Prof. Jinyu Wang and Prof. Shunfeng Yang

- Special Session on Dynamic Modeling, Stability, and Control of Power Electronics Dominated Power System
  Organizers: Yang Han, Amr Salah, Jiawei Chen, Xin Zhao, Yajuan Guan and Tao Huang

- Special Session on Modelling and Control of Space Precision Systems
  Organizers: Prof. Lei Liu and Prof. Qing Li

- Special Session on Data Analysis and Optimal Scheduling
  Organizers: Prof. Jin Xiao and Prof. Guofeng Zhang

- Special Session on System Control and Modeling
  Organizers: Prof. Xiantao Sun and Prof. Min Zhu

- Special Session on Energy and Environment
  Organizers: Prof. Chao Lyu and Prof. Chao Zhang

- Special Session on Intelligent Computing and Pattern Recognition
  Organizers: Prof. Chao Lyu and Prof. Chao Zhang

- Special Session on Power Electronics
  Organizers:: Prof. Jian Huang and Prof. Shuai Wu

- Special Session on State Monitoring and Prediction
  Organizers:: Dr. Nalini Rizkyta Nusantika and Prof. Jiting Li

- Poster Session
  Organizers:: Prof. Weihai Chen and Prof. Yunhua Li

Keynote Speeches

Keynote Speech I

Date/Time: 2 August 2021, 09:00 - 10:00 (UTC+8)

Session Chair: Prof. Changyun Wen

Leveraging Old Tricks in A New World: Efficient Generation of Labeled Data for Deep Learning

Professor Gaurav Sharma

Department of Electrical and Computer Engineering Department of Computer Science University of Rochester, USA

Biography

Gaurav Sharma is a professor in the Departments of Electrical and Computer Engineering, Computer Science, and Biostatistics and Computational Biology, and a Distinguished Researcher in Center of Excellence in Data Science (CoE) at the Goergen Institute for Data Science at the University of Rochester. He received the PhD degree in Electrical and Computer engineering from North Carolina State University, Raleigh in 1996. From 1993 through 2003, he was with the Xerox Innovation group in Webster, NY, most recently in the position of Principal Scientist and Project Leader. His research interests include data analytics, cyber physical systems, signal and image processing, computer vision, and media security; areas in which he has 54 patents and has authored over 220 journal and conference publications. He served as the Editor-in-Chief for the IEEE Transactions on Image Processing from 2018 through 2020, and for the Journal of Electronic Imaging from 2011 through 2015. He is a member of the IEEE Publications, Products, and Services Board (PSPB) and chaired the IEEE Conference Publications Committee in 2017-18. He is the editor of the Digital Color Imaging Handbook published by CRC press in 2003. Dr. Sharma is a fellow of the IEEE, a fellow of SPIE, a fellow of the Society for Imaging Science and Technology (IS&T) and has been elected to Sigma Xi, Phi Kappa Phi, and Pi Mu Epsilon. In recognition of his research contributions, he received an IEEE Region I technical innovation award in 2008 and the IS&T Bowman award in 2021. Dr. Sharma is a 2020-2021 Distinguished Lecturer for the IEEE Signal Processing Society.

Abstract

In the emerging world of artificial intelligence algorithms and analytics, curated and labeled data is often considered the new oil. However, extracting this oil is often expensive and fraught with difficulties. Specifically, generation of labeled data can be labor intensive and tedious. Crowd sourcing can distribute the labor and mitigate the cost and tedium for some application scenarios. However, for other applications, such as medicine, the requirement of specialized knowledge and skills can make crowd sourcing unviable and generation of labeled data is therefore both expensive and limited, in volume and accuracy, by the availability of physicians time. The problem is even more acute for tasks requiring sample level labeling of large, high-resolution spatio-temporal datasets, for example, for pixel-level labeling of images for medical image segmentation. In this talk, through case studies, we highlight examples where creative use of conventional machine learning, computer vision, and image processing techniques allows us to efficiently generate labeled data for new applications of deep learning. The examples particularly highlight that these conventional tools continue to be effective and useful and will therefore co-exist symbiotically with modern deep learning methodologies.

Technical Programme

ICIEA 2021 — Technical Programme

Pre-Recording Sessions will be online for viewing from 1 - 14 August 2021 Questions can be sent to each presenter's email in the list.

Session Best Paper Award Selection
Date 1 – 14 August 2021

P1301 **Pg 3**

A Distributed Fusion LSTM Model to Forecast Temperature and Relative Humidity in Smart Buildings

Xiwen Wang[1], Xinli Wang[1], Lei Wang[1], Lianjie Jiang[1] and Youjie Zhan[2]
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P1202 **Pg 3**

Modeling and Mitigating LED Nonlinearity using Nonlinear ARX model with Wavelet Networks

Jundao Mo[1,a], Xiong Deng[1,3,f], Wenxiang Fan[1,b], Yinan Niu[1,c], Yixian Dong[2,e], Guofu Zhou[1,d] and Jean-Paul Linnartz[3,g]
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[3]*Department of Electrical Engineering, Eindhoven University of Technology, Eindhoven, Netherlands.*

P1346 **Pg 3**

Backstepping-Based Adaptive Control for Uncertain Fractional-Order Nonlinear Systems

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P1258 **Pg 3**

Power Flow Flexible Operation Analysis for Series-Parallel Architecture Region Energy Router

Yingrui Liu[a], Xiaojun Zhao[b], Xiaohuang Wang[c], Di Zhang[d], Chunjiang Zhang[e] and Xiaoqiang Guo[f]
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P1244 **Pg 4**

Structural Design of A Novel Electromagnetic Driven Spherical Motion Generator

Jingmeng Liu[a], Xiaofeng Guo[b], Zhong Liu[c] and Yukun Wang[d]
School of Automation Science and Electrical Engineering, Beihang University, Beijing, China

P1177 **Pg 4**

A Novel Method of Open Circuit Voltage Reconstruction for $LiFePO_4$ Battery based on Incremental Capacity Analysis

Yong Tang[a], Tao Jiang[b], Saihan Chen[c], Shengshi Qiu[d] and Jinlei Sun[e]
Nanjing University of Science and Technology, School of Automation Nanjing, China

Session TT01 Artificial Intelligence (1)
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P1031 **Pg 5**

Cherrypick: Solving the Steiner Tree Problem in Graphs using Deep Reinforcement Learning

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P1078 **Pg 5**

Research on Image Classification Algorithm Based on DenseNet for Small Sample in Industrial Field

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P1309 **Pg 9**

Synthesised Optimal Control for a Robotic Group by Complete Binary Genetic Programming

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P1334 **Pg 9**

Text Classification Model Based on BERT-Capsule with Integrated Deep Learning

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Session TT03 Control and Systems (1)
Date 1 – 14 August 2021

P1025 **Pg 9**

Research on H_∞ Robust Frequency Control Strategy with Temperature Control Load

Weiming Huang, Mi Dong, Li Li[a] and Han Gao
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P1041 **Pg 10**

Preview Control of Semi-Active Suspension with Adjustable Damping Based on Machine Vision

Huize Hu[a], Guangqiang Wu[b] and Libo Mao[c]
School of Automotive Studies, Tongji University, Shanghai, China.

P1049 **Pg 10**

Thermostatically Controlled Loads Participating in Microgrid Regulation Strategy Based on Model Prediction

Han Gao, Mi Dong, Li Li[a] and Weiming Huang
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P1053 **Pg 10**

Study on Control Strategy of Wind Farm Combined with Energy Storage System

Junrui Wang[a], Jingchao Zhou[b], Libao Wang[c], Chuang Wang[d], Xinju Wu[e] and Li Dai[f]
School of Electrical Information Engineering, North Minzu University, Yinchuan, China

P1073 **Pg 10**

A New Designed Intelligent Weelchair with Elevating Lazyback

Cheng Shen[1], Qiuping Bi[2,3], Huanzhi Lou[4,a] and Huiyin Xu[4,b]
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P1075 **Pg 11**

Adhesion Control of High Speed Train Based on Vehicle-control System

Song Wang[a], Xiongguo Wang[b], Jingchun Huang[c], Pengfei Sun[d] and Qingyuan Wang[e]
School of Electrical Engineering, Southwest Jiaotong University, Chengdu, China

P1093 **Pg 11**

Development of Control System for a High-Speed Permanent-Magnet BLDCM

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Session TT04 Control and Systems (2)
Date 1 – 14 August 2021

P1159 **Pg 11**

Fault Tolerant Control Strategy Based on Model Predictive Control and Unscented Kalman Filter for Permanent Magnet Synchronous Motor

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P1228 **Pg 12**

Disturbance Observer Based Adaptive Fuzzy Sliding Mode Controller for Cable Arrangement System

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P1270 **Pg 12**

Optimal Vibration Analysis for A Combustion Motor

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P1298 **Pg 12**

Adaptive Sliding Mode Control for Steer-by-Wire Road Vehicle Systems based on Dynamic Parameter Estimation

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P1310 **Pg 13**

Trajectory Control in Non-Minimum Phase Plants

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P1318 **Pg 13**

Contour Error Compensation based on Feed Rate Adjustment

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P1324 **Pg 13**

Remote Current and Voltage Monitoring System Based on Cloud Storage and Wireless Communication Technology

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P1330 **Pg 14**

Hierarchical Voltage/Var Optimization Control of a Wind Farm

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P1356 **Pg 14**

Research on Trigonometric Velocity Scheduling Algorithm of Five-axis CNC System Based on Constraints

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P1410 **Pg 18**

Fuzzy Fault Detection Observer Design for Head-Two-Arms-Trunk System

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Session TT07 Energy and Environment (1)

Date 1 – 14 August 2021

P1065 **Pg 18**

Optimization of Particle Swarm based MPPT under Partial Shading Conditions in Photovoltaic Systems

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P1102 **Pg 18**

Design and Implementation of a Low-Speed Wind Tunnel System

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P1139 **Pg 18**

Radial Electromagnetic Force Analysis of Rotary Transformer Based on Inductive Energy Transmission

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P1161 **Pg 19**

Optimal Configuration of Concentrating Solar Power and Energy Storage System in 100% Renewable Energy Systems

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P1212 **Pg 19**

Research on Wireless Heating Device for Power Lithium-Ion Battery

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P1231 **Pg 19**

IIoT-enabled and Data-driven Sustainability Evaluation Framework for Textile Supply Chain

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P1247 **Pg 20**

Rolling Optimal Dispatch Strategy of Prosumer Considering Grid-Connected Power Fluctuation Suppression and Energy Storage Degradation Cost

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Session TT08 Energy and Environment (2)

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P1248 **Pg 20**

Research on Data Acquisition System of Six-Dimensional Force Sensor

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P1266 **Pg 20**

A Cooling Capacity Distribution Method For Liquid Cooling Cycle Based on Co-Simulation and Optimization of AMESim and modeFRONTIER

Liu Haodong[1,a], Dong Sujun[2,c], Jiang Hongsheng[2,d] and Li Yunhua[1,b]
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P1353 **Pg 21**

Two-stage Distribution Network Reconfiguration Method Considering Load Type and Overload Rate

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P1072 **Pg 21**

The Influence of Different Factors on the Power-Generation Performance of Reverse Electrodialysis

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P1104 **Pg 21**

Energy Trading Method of Distribution Network System with Multi-Microgrid Based on Stackelberg Game

Zhenfeng Lin[1,a], Debao Huang[2,3], Deling Li[2,3], Xian Yang[2,3], Qunjing Wang[1,4], Changbao Zheng[1,5] and Cungang Hu[1,6]
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P1105 **Pg 22**

Nash Bargaining Based Active and Reactive Energy Trading Method for Microgrids in Distribution Network

Fan Zhou[1,a], Debao Huang[2,3], Deling Li[2,3], Xian Yang[2,3], Qunjing Wang[1,4], Changbao Zheng[1,5] and Cungang Hu[1,6]
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P1164 **Pg 22**

Vulnerability Analysis of Power System with Wind Farm Integrated Considering High-Speed Rail Loads

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P1187 **Pg 23**

Design And Analysis of Flexible Haptical System Based on Varistor Sensor Array

Zhaozhou Xin[1], Zhuoyuan Chen[1], Shaoping Wang[2], Chao Zhang[1], Dong Liu[1] and Yi Wang[1,a]
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P1235 **Pg 23**

Primary Frequency Regulation Technology of Power Grid and Frequency Regulation Potential Analysis of Hydrogen Fuel Cell

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P1272 **Pg 23**

Numerical Simulation of Internal Flow in Jumper Tube with Blind Tee

Yuxiang Liu[1], Fenghui Han[2,a], Hefu Zhang[1], Dongxing Wang[1], Zhe Wang[1] and Wenhua Li[2]
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P1273 **Pg 24**

Study on Working Medium Selection of High and Low Temperature Coupled ORC Scheme for Waste Heat Recovery of Dual-Fuel Ship Engine

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Integrated Optimization for Energy-saving Operation in Co-phase TPSS

Wenjie Lu[a], Minwu Chen[b], Meng Wang[c], Yingtao Chen[d], Zhechao Kou[e] and Haochun Fu[f]
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P1313 **Pg 24**

Analysis of Air Gap Correction Method for 27.5kv Traction Power Supply System of Highland Electrified Railway

Ke Chen, Jia Yang, Jiayi Zhang and Jingwen Liang
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P1332 **Pg 25**

Robust Game Optimization Scheduling Method for User-side Distributed Energy Storage

Debao Huang[1,2], Deling Li[1,2], Xian Yang[1,2], Cungang Hu[1,2] and Zhenfeng Lin[1,2]
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P1357 **Pg 25**

Review on the Risk and Treatment of Electric Vehicle Charging Pile Charging Leakage

Sanjun Xie[1,a], Wenjie Zhu[2], Yuhuan Niu[3], Yan Zhao[1,b], Mengya Zheng[4] and Bo Liu[5]
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Session TT10 Energy and Environment (4)

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P1367 **Pg 25**

Research on Prediction of Photovoltaic Power Generation Probability Interval Based on Gaussian Mixture Model

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P1393 **Pg 26**

Multi-core Identification of Mixed Power Disturbances

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Optimal Power Distribution of Fuel Cell Electric Trucks via Convex Programming

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P1009 **Pg 26**

Optimal Scheduling of HESS for FTPSS Considering HESS Degradation Cost

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P1262 **Pg 27**

Lithium-ion Battery SOC Estimation Based on an Improved Adaptive Extended Kalman Filter

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Multi-Region Distributed State Estimation Method for Natural Gas System

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Session TT11 Industrial Informatics and Computational Intelligence (1)
Date 1 – 14 August 2021

P1039 **Pg 27**

Automation Disassembly Sequence Generation Based on Visual Recognition and Rules in Remanufacturing

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P1091 **Pg 28**

A Precise Measure Method for the Unbalancing Vector of Spindle in Ultra-precision Diamond Turning

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Job Shop Scheduling in Discrete Manufacturing Based on Improved Hybrid Lion Swarm Optimization

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P1098 **Pg 28**

Intelligent Appearance Quality Detection of Air Conditioner External Unit and Dataset Construction

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P1154 **Pg 28**

Fault Diagnosis of Series Batteries based on GWO-SVM

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P1219 **Pg 29**

A Power Grid Fault Center Identification Method Based on Feature Vector Centrality

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P1379 **Pg 29**

Technology Network Construction and Analysis Method for Technology Trends Discovery

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Session TT12 Industrial Informatics and Computational Intelligence (2)
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P1408 **Pg 29**

Multi-Agent Reinforcement Learning-based Distributed Economic Dispatch Considering Network Attacks and Uncertain Costs

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The Circuit Fault Diagnosis Method Based on Spectrum Analyses and ELM

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A Real-time Reconfigurable Edge computing System in Industrial Internet of Things Based on FPGA

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Design and Expansion Development of Embedded System Software for a New Intelligent Hematology Analyzer

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D-Optimal Design for Information Driven Identification of Static Nonlinear Elements

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DRAT : A Penetration Testing Framework for Drones

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Fair Rewarding Mechanism for Sharding-based Blockchain Networks with Low-powered Devices in the Internet of Things

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Latency Estimation of Blockchain-Based Distributed Access Control for Cyber Infrastructure in the IoT Environment

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Hubble: An End to End Approach for Anomaly Detection in Network Traffic

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Design of Real-time Video Transmission System Based On 5G Network

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Research of Webpage Complexity Influence on Search Behavior Based on Eye Tracking Experiment

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Design of UAV Video And Control Signal Real-Time Transmission System Based on 5G Network

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Research on Information Interaction Scheme of Charging Pile based on IEC61850

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A Charging Station Centric Cooperative Edge Computing Architecture for Computation of Electric Vehicles and Charging Facilities

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Transient Analysis of the Suspension Electromagnet Winding Terminal Current

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Robust Impedance Reshaping of Multiple Ongrid Inverters regarding Variable Grid Conditions

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Comparison of Different Neutral Point Balance Strategies Applied to Three-Level DFIG System

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Power Characteristic Analysis of PMSG Based on Voltage Source Control

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Fault Ride-Through Control Strategy of Doubly-Fed Wind Turbine Under Symmetrical Grid Faults

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Enhanced Efficiency of Wireless Power Transfer Using Slotting in the Metals

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An Adaptive Robust Predictive Current Control Scheme With Online Parameter Identification Based on MRAS for High-Performance PMLSM Drives

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Modeling and Matlab Simulation of the Inverter Based on Bond Graph

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Research on MPPT of Photovoltaic Power Generation based on Backstepping Method

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Experimental and Variance Analysis on Flame Propagation Behaviors in Coal Dust Explosions

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Optimization of Complex Mine Ventilation System Based on AHP-WRSR

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Dosimetry Simulation Research on Electromagnetic Exposure of Wireless Charging Electric Vehicle to Human Central Nervous System

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Study on Active Resistance Design Methods for Digital Current Controllers of IPMSM

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Study on a High-Efficiency DC/DC Converter for a Class of Space Fuel Cell Driving Power

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Research on Grid-side Control for a Medium Voltage Direct-Connected Cascaded Inverter Based on Model Predictive Control Under Weak Grid Conditions

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A Fast Switching Superjunction IGBT with Segmented Anode NPN

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Impedance modeling and resonance suppression strategy of voltage source DFIG

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Design and Optimization of Modular Multilevel DC Transformer

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Analysis and Design of Modular Multi-level DC/DC Converter

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Design of Information Management System for Large Modular Manned Spacecraft

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A Dual-Input High Step-up Photovoltaic Power Optimizer with Integrated Energy Storage

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A Portable Impedance Measurement Device with Controllable Broadband for Power Grid

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An Overcompensated Design Method for Series-Series Compensated Wireless Power Transfer Systems

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An Improved Model Predictive Control of Virtual Synchronous Generator for an Islanded AC Microgrid

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Research on Improving the Fault Simulation Accuracy of Modular Multilevel Converters

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Half Bridge LLC resonant Converter Design for Wide Input Voltage Range Applications

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Analysis and Optimal Parameter Selection of Full Bridge Bidirectional CLLC Converter for EV

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Charge-biased Synchronized Triple Bias Flip Circuit for Piezoelectric Energy Harvesting

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Multi-objective Optimization Design of Spherical Induction Motor

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Analysis of the Influence of Voids in Solder Layer on IGBT Failure based on ANSYS

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Reliability Modeling and Simulation Analysis of IGBT Devices based on Saber Software

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A Research on Inductance Forcedly Absorbing Current to Reduce Stray Current in Metro

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Degradation Assessment of Photovoltaic Module Based on Probability Distribution Analysis of Model Parameters

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Adaptive Terminal Sliding Mode Control for Magnetic Levitation System With Observer

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Optimization of Magnetic Coupling Resonance Coils

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Capacitive Coupling Wireless Energy Transmission Constant Voltage System Based On Composite Network Resonance

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Inverter Fault Diagnosis Based on Optimized BP Neural Network

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Research on Honeycomb Multi-Station Integration System

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A Neutral-Point Potential Balanced Deadbeat Direct Torque Control Strategy of Post-Fault Three-Level NPC Inverter-Fed Induction Motor Drives

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Adaptive Tuning of Phase-Locked Loop Parameters for Grid-Connected Inverters in Weak Grid Cases

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Analysis of Fault Detection Based on Least Squares Approach for BDS Integrity Monitoring

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Research on the Degradation Characteristics of IGBT Safe Operation Area(SOA) in Traction Converter

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A Voltage Differential and Pulse Synchronous Driving Control of Paralleled IGBTs for Current Balance Improving

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Study of The Power-Load Characteristics in A Widely Adapted Driver Circuit for Several Types Power Semiconductor Device

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Research on Fault Diagnosis and Reconfiguration Strategy of Single-Phase Three-Level Cascaded Inverter

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Research on Dead Time of Half-Bridge LLC Resonant Circuit Based on SiC MOSFET

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Diagnosis of Open Circuit Faults for Three-Phase Three-Level Converters Based on the Change Rate of Current Residual

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The Single-Phase Virtual Synchronous Machine Control Strategy of the Advanced Co-phase Traction Power Supply System

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Research on DC-DC Converter for High Speed Train Auxiliary Power Supply System

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Measurement and Control System of Pulse Power Supply Based on HTSPPT

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Thermal Analysis of Press-pack IGBT in Hybrid DC Circuit Breaker

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FPGA Controller Based Bidirectional CLLC Resonant Battery Charger

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Design and Comparison of High-Order Output Filters for Grid-Connected Converters with Low Switching Frequency

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Research on Predictive Direct Power Control of Three-phase Separated Hybrid Power Electronic Transformer

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Research on Voice Coil Motor Control Considering Interference

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Research on Symmetrical Switched Capacitor Multilevel AC-AC Converter

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Analysis and Implementation of Input Parallel Output Parallel DAHB DC-DC Converters with Sensorless Current Sharing Control Strategy

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High Power Driving and Control of Electrical Cylinder in Aerospace Erection System

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A Voltage Balancing Circuit Based on LC Unit with Dual LC Resonant Tanks

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Smart Power Supply System Based on Parallel DC-DC Modules

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A Hybrid Single-Phase to Three-Phase Power Supply System With Voltage Error Compensation Strategy

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A MPPT Control Method Based on the Improved Wind-Driven Optimization

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ZVS Analysis and Control Strategy for Back-Stageof Single-Phase AC-DC-DC Converter With Low-Frequency DC-Link Voltage Ripple

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Research on Magnetic Integration Coupling Mechanism of UAV Wireless Power Transfer System

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Session TT27 Power Electronics (13)
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Power Balance Strategy of Cascaded DC Solid State Transformer Based on Virtual Impedence

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Optimized Design and Simulation Study of Helical Core Suitable for Non-invasive Energy Harvesting

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A Data-Driven Topology Estimation For Distribution Grid

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Comprehensive Benefit Evaluation of Distributed Photovoltaic Power Generation System with DC Interconnection Based on Benefit-Cost Ratio

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Energy-Based Large-Signal Stability Analysis of DC Microgrid Considering Dynamic Interactions Between Multiple Converters

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Large Signal Stability Analysis of Multi-Voltage Level DC System

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Analysis for Reduced-order Model of a Typical Photovoltaic-battery Hybrid Power System

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Research on Multi-objective Optimal Scheduling of Active Distribution Network Based on Cluster Partition

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Mechanical design and Optimization on a Home-based Upper Limb Rehabilitation Robot

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Path Planning of Six-Axis Manipulator Based on ROS System

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P1100 **Pg 65**

Multi-Obstacle Detection Based on Monocular Vision for UAV

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P1130 **Pg 65**

A Feasible Method for Evaluating Energy Consumption of Industrial Robots

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Design, Modeling and Control of a Novel Over-Actuated Hexacopter with Tiltable Rotors

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Control a Fully Actuated Aerial Vehicle under Impact of Wind Disturbance

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Design of a Path-Following Controller Based on A New Tracked Vehicle Kinematics Model

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Session TT29 Robotics (2)
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Graph-based Extrinsic Calibration of Multiple 2D-Lidars

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P1409 **Pg 66**

A Review of Compliant Control for Collaborative Robots

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Session TT30 Signal and Information Processing (1)
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Session TT31 Signal and Information Processing (2)
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Robust Filtering of Affine-Projection-Like Maximum Correntropy Algorithm with Bias-Compensated

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Hyperbolic Secant Function Algorithms for Nonlinear Active Noise Control models of Kernel Mapping Types

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An Improved Unsupervised Color Correction Algorithm for Underwater Image

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Augmented Complex Least Mean Square/Fourth Algorithm for Adaptive Frequency Estimation

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Session TT33 Signal and Information Processing (4)
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Supraharmonics Transfer Characteristics of Transformer

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The Tikhonov Regularization Method Improved by Genetic Algorithm is used to Retrieve the Non-Spherical Particle Spectral Distribution

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Short Term Estimation of Environmental Variables for Improving The Fault Tolerance of Distributed Control Networks

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Non-Contact Vital Signs Detection Using mm-Wave Radar During Random Body Movements

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Machine Vision Based Autonomous Loading Perception for Super-huge Mining Excavator

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Session SS01 Advanced Techniques and Emerging Applications of Modular Multilevel Converters
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Research on Influencing Factors of Voltage Control for MMC type Mobile DC Ice Melting Device

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SVG Control Function and Realization of Modular Multi-Level DC Ice Melting Device

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Session SS02 Application of data science and technology in the Energy Internet
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Graph Matrix Completion for Power Product Recommendation

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A Data Processing Method for Mountain Photovoltaic Power Plants Based on Time and Space Characteristics

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Research on the Fault-Diagnosing Method in the Operation of the Threshing Cylinder of the Combine Harvester

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A Fast Modeling Method using Limited Resources for 3D Campus

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An Adaptive Power Grid Friendly Response Strategy for Commercial Buildings Based on Power Cyber-physical System

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Ensemble Empirical mode Decomposition Based Electrical Power Demand Forecasting for Industrial User

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An Explainable Recurrent Neural Network for Solar Irradiance Forecasting

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Session SS03 Artificial Intelligence for Industrial Internet of Things (IIoT) (1)
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Energy-Efficient NOMA with QoS-Guaranteed Power Allocation for Multi-User VLC

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OFDM-Based Generalized Spatial Modulation for Optical Wireless Communication

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Joint Detection for Generalized Optical MIMO: A Deep Learning Approach

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LED Nonlinearity Post-compensator with Legendre Polynomials in Visible Light Communications

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Fault Detection of Air-spring Devices Based on GANomaly and Isolated Forest Algorithms

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Collaborative Edge Network Research and Design Based on Ant Colony Algorithm for IoT

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Achievable Rate of MIMO-OFDM VLC over Low-Pass Channels

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Session SS04 Artificial Intelligence for Industrial Internet of Things (IIoT) (2)
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Fault Feature Selection of Subway Plug Door Based on ReliefF and BGWO

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Face Image Based Automatic Diagnosis by Deep Neural Networks

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Deep Learning Based Load and Position Identification of Complex Structure

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The Early Prediction of Lithium-Ion Battery Remaining Useful Life Using A Novel Long Short-Term Memory Network

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Interpretation of DGA for Transformer Fault Diagnosis with Step-by-step Feature Selection and SCA-RVM

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Dual Redundancy Fault Diagnosis and Reconstruction System of Sensors Based on BP Neural Network

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Transformer Fault Diagnosis Based on BP Neural Network Optimized by The Strongest Crow Search Algorith

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Session SS05 Computer Vision and Image Processing for Engineering and Biomedical Applications (1)
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Parallel and Pipelining design of SLAM Feature Detection Algorithm in Hardware

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Fault Diagnosis of Train Clamp Based on Faster R-CNN and One-class Convolutional Neural Network

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Defects Detection of Dispensing Products With an Improved ICP Algorithm

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Feature Point Screening For Image Matching

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An Evaluation of Machine Learning Frameworks

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Visual Measurement of Levitation Gap in Maglev Ball System Based on Pixel Area

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Video Summary Generation Based on Density Peaks Clustering with Temporal Characteristics

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Session SS06 Computer Vision and Image Processing for Engineering and Biomedical Applications (2)
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Background Separation Based on Dual-Weighted Robust Principle Component Analysis

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Histogram-based Fuzzy C-Means Clustering for Image Binarization

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A Text Correction and Recognition for Intelligent Railway Drawing Detection

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LERANet: Low-light Enhancement Network based on Retinex and Attention

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Crack Detection on Aircraft Composite Structures Using Faster R-CNN

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Improving Recognition Performance for Low-Resolution Images Using DBPN

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Session SS07 Data Analysis and Optimal Scheduling (1)n
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The Optimization Strategy of Tests for Fault Isolation Based on Rollout Algorithm

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Traffic PowerFlow:A Time-space Network based Program for Optimal Traffic Power Flow Analysis

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Research on Fault-phase Selection of New High-Speed Railway Continuous Power Line Based on Wavelet Transform

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Research on EV Charging Station Capacity under Multi-price Scale

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Research of Fault Diagnosis Method for New High-speed Railway Single Power Distribution Station Based on Bayesian Network

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Session SS08 Data Analysis and Optimal Scheduling (2)
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Transformation from System Model to FACE Data Model Based on Metadata Mapping

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Adaptive Gait Generation Based on Pose Graph Optimization for Lower-Limb Rehabilitation Exoskeleton Robot

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Mission Oriented Flocking and Distributed Formation Control of UAVs

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Performance Analysis and Comparison of Four Conventional Multi-objective Optimization Algorithms

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Session SS09 Dynamic Modeling, Stability, and Control of Power Electronics Dominated Power System (1)
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Yaw Stability Control for 6WD Unmanned Vehicle on Split-mu Road Using Sliding Mode Algorithm

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Effectiveness Analysis of Evaluating Continuous Commutation Failure With Short Circuit Ratio

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Low-Frequency Oscillation Analysis of Train-Network System with Different Types of Trains Connected

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A Hierarchic Control Strategy for Reliability Enhancement of PFCs in Co-phase TPSS

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Supplementary Damping Controller Design of DFIG With Mode-based Damping Torque Analysis Method

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Low Voltage Ride Through of Voltage Source Converters With Droop Control

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Fault Prediction of Power Electronic Devices in Mobile UPS System

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Session SS10 Dynamic Modeling, Stability, and Control of Power Electronics Dominated Power System (2)
Date 1 – 14 August 2021

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Rapid Power Control and MPPT Method of Voltage Controlled Grid-connected Inverters In Very Weak Grids

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Influence Factors Analysis of Transient Power Angle Instability Caused by Commutation Failures

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An Accurate Linearized model of Synchronous Reference Frame Phase-Locked Loop

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A Benchmark Model of Grid-Connected Conversion System for Control Interaction Caused Oscillation Problems

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Analysis of Subsynchronous Oscillation Characteristics of Hybrid-Based Wind Farm Connected With Fixed Series Compensation System

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Comparative Analysis of Two Kinds of Subsynchronous Oscillation of Direct Drive PMSG based Wind Farm Dominated by Inner Current Loop

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Session SS11 Energy management of new energy vehicle
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Remaining Useful Life Estimation of Battery based on MEKF

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Joint Estimation of State of Charge and Capacity of Lithium-ion Batteries in Electric Vehicle

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Online Joint Estimation of SOC and SOP for Highrate Battery based on EKF

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SOC Estimation of Extended Kalman Filter Based on Hardware-in-the-Loop Simulation Platform

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Regrouping Optimization Method for Retired Batteries based on Particle Swarm Optimization Algorithm

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State Estimation of Lithium-Ion Battery at Different Temperatures Based on DEKF and RLS

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Modeling and Simulation of Fuel Cell Buses

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Session SS12 Intelligent Computing and Pattern Recognition (1)
Date 1 – 14 August 2021

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Fault Diagnosis of Subway Plug Door based on EEMD and Adaptive Feature Extraction

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A Method for Predicting the Quality of Slabs Based on GA-RF Algorithm

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Research on Digital Imaging Simulation Method of Space Target Navigation Camera

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Object SLAM with Dual Quadric Parameterization

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Stereo-based Terrain Parameters Estimation for Lower Limb Exoskeleton

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Application of VMD Combined with CNN and LSTM in Motor Bearing Fault

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Human Action Recognition Based on State Detection in Low-resolution Infrared Video

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Session SS13 Intelligent Computing and Pattern Recognition (2)
Date 1 – 14 August 2021

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Gestures recognition of sEMG signal based on Random Forest

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Prediction of Lower Limb Action Intention Based on Surface EMG Signal

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Radar Emitter Identification Based on Co-clustering and Transfer Learning

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Transformer-Based End-to-End Scene Text Recognition

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Session SS14 Intelligent control and optimization of Heating, Ventilation and Air Conditioning (HVAC) System
Date 1 – 14 August 2021

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Prediction of Air Conditioning Energy Consumption Based on BP Neural Networks with an Each-Column Optimization Synthesis Algorithm

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P1304 **Pg 104**

Fault Detection and Isolation for Chiller System based on Deep Autoencoder

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Optimization of A Boil-Off-Gas Reliquefaction System for Small-Scale Liquefied Natural Gas Fueling Stations

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Removal of R134a from air/R134a Mixture Based on Cryogenic Condensation Method

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A Multi-Objective Optimization Of Energy Consumption and Thermal Comfort for Active Chilled Beam Systems

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A Hybrid ANN-LSTM Based Model for Indoor Temperature Prediction

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Optimization of Solar Collector and Heat Storage Tank for Solar Absorption Refrigeration

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Session SS15 Model predictive control for power converters
Date 1 – 14 August 2021

P1008 **Pg 106**

Tolerant Sequential Model Predictive Voltage Control for the Neutral-Point Clamped Three-Level Three-Phase Inverters

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Current-sensorless Finite-Control-Set Model Predictive Control for Three-level Voltage Source Inverter

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Multi-stage Series Model Predictive Torque Control for SPMSM Drives

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Session SS16 Modelling and Control of Space Precision Systems
Date 1 – 14 August 2021

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A Fuzzy PI Controller for Piezoelectric Fast Mirror Based on Particle Swarm Optimization

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Surface Control of Large Deployable Membrane Diffraction Antenna

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Development of Ultra-quiet Gravity Unloading for Micro-vibration Testing of Space Precision Payloads

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Acquisition, Scanning and Control Technology for Inter-satellite Laser Communication

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Session SS17 Future Robotics
Date 1 – 14 August 2021

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Intent Prediction of Pedestrians via Integration of Facial Expression and Human 2D Skeleton for Autonomous Car-like Mobile Robots

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Multi-scale Extreme Exposure Images Fusion Based on Deep Learning

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Global Path Planning for Fire-Fighting Robot Based on Advanced Bi-RRT Algorithm

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Vision-Based Formation Control for a Heterogeneous Multi-Robot System

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Model and Data Driven Pseudo-HDR Imaging

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Session SS18 State Monitoring and Prediction
Date 1 – 14 August 2021

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Simulation Analysis of Inconsistency of Series-connected Batteries under Constant Current Condition

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P1162 **Pg 110**

Dynamic Performance of DAB with ModelPredictive Control Based on Double Phase Shifting

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P1206 **Pg 110**

Design of Embedded Remote Working Condition Monitoring System Based on Wireless Network Bridge

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Design of A Fast Measuring System for Electrochemical Impedance Spectroscopy of Lithium-Ion Battery

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Adaptive Model Predictive Control with Particle Filter for Artificial Pancreas

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Review of Rotor Position and Speed Estimation Method of PMSM with Hall Sensor

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Improvement Canny Edge Detection for the UAV Icing Monitoring of Transmission Line Icing

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Strength Analysis for Bolted Joints Fastening the Underframe Equipment of EMU

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Session SS19 System Control and Modeling (1)
Date 1 – 14 August 2021

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Visual Management Method Applied for R&D Project Management: A Case Study

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Robust Sliding Mode-Based Learning Control for Lane-Keeping Systems in Autonomous Vehicles

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Path Optimization of Intelligent Wheelchair Based on an Improved Ant Colony Algorithm

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Cross Regulation Analysis of Voltage-Mode Controlled SIDO Buck LED Driver

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Modeling and Simulating of Single Autonomous Vehicle Under Urban Conventional Traffic Flow

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On the Combination of PID control and Reinforcement Learning: A Case Study with Water Tank System

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Dynamic State Estimation of Smart Grid Based on CKF under False Data Injection Attacks

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Day-Ahead Economic Dispatch of Integrated Energy System Including Power to Gas

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Distributed Fixed-Time Secondary Frequency Control of MTDC Systems

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Robust H_∞ Cruise Control of High-Speed Train with Parameter Uncertainties, Time-varying Delays and Disturbance

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Navigation Stack for the Crawler Robot Servosila Engineer

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Mobile Application for Controlling Multiple Robots

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Two-time-scale Containment Control of Multi-agent Systems with State-dependent Switching Topology

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Fault Diagnosis of Cascaded NPC Inverter Based on Single Sensor

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A Novel AC-DC Hybrid Metro Power Supply System

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Control by Equilibrium

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Linearization Design of Servo System and Parameter Identification Based on LuGre Model

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Practical Fuzzy Repetitive Control for Accurate Amplitude and Phase Tracking in Linear Compressor

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Lower Limb Rehabilitation Exoskeleton Control based on SSVEP-BCI

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An Adaptive Control Approach of Body Weight Support System for Lower Limb Exoskeleton Based on Trajectory Feedforward

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An Integration Method of Heterogeneous Models for Process Scheduling Based on Deep Q-Learning Integration Agent

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Fuzzy Unknown Input Observer Design for Autonomous Ground Vehicles

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Four-Consecutive-Samples based Frequency Estimation for Three-Phase Grids with DC-offsets

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Performance Comparison of DSTATCOM using SRF and IRP Control Algorithm

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The Mechatronic System Design of the Bed-Chair Integration System E-Bed

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Analysis of the Movement Mechanism of the In-oil Storage Tank Floor Inspection Robot

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Research on Track/Hold Circuit Based on Feedback Compensation

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UCB-ENAS based on Reinforcement Learning

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A Fault Diagnosis Framework for Aircraft Electromechanical System

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Control Strategy of Rope Driven Upper Exoskeleton Robot Based on Screw Method

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Design and Stiffness Analysis of a Cable-Driven Continuum Manipulator

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A Comparative Study of Different Models in Ancient Poetry Translation

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Trajectory Design and Adaptive Impedance Control of Lower Limb Exoskeleton

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1-bit WaveNet: Compressing a Generative Neural Network in Speech Recognition with Two Binarized Methods

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Research on Three-Level Bi-Directional DC-DC Converter and Its Control Strategy Used for Energy Storage System of Electric Wheeled Tramcar

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Development of Cascade H Bridge SVG

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Modeling of Peripheral Circuit of Bus-integrated Computer Based on Saber

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Research on Modeling Method of Aeronautical Weapon Flight Control System Based on Harmony-SE

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Route Planning of Mixed Ant Colony Algorithm Based on Dubins Path

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Distributed Optimal Power Dispatch Based on Bisection Lambda Iteration Algorithm for Microgrids

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Adaptive Backstepping Control of Uncertain Electro-Hydrostatic Actuator with Unknown Dead-zone Nonlinearity

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Research on Rotor Position Estimation of PMSM Based on Hall Position Sensor

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Human-machine Coupled Research of a Passive Lower Limb Exoskeleton for Walking Assistance

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Design and Optimization of Human-Machine Interaction Wearable Device for Lower Limb Rehabilitation Exoskeleton

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Formation Control and Obstacle Avoidance of Mas With Constraints of Visibility and Motion Saturation

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Evaluation of Transformer Bushing Moisture Faults Based on Clustering Algorithms and TOPSIS

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Key Factors Affecting the Corona Onset Voltage of Electrostatic Precipitator Electrodes

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Wear Modelling of Slipper/Swashplate Pair for High-Speed Piston Pump Under Transient Lubrication Conditions

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Learning From Demonstration Using Improved Dynamic Movement Primitives

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Toward Obstacle Avoidance for Mobile Robots Using Deep Reinforcement Learning Algorithm

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Torque Density Optimization of Six-phase Permanent Magnet Synchronous Machine

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Design and Optimization of BLDC Machine for Bidirectional Impeller Pump

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Abstracts

Abstracts

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P1301

Traffic PowerFlow:A Time-space Network based Program for Optimal Traffic Power Flow Analysis

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With transportation electrification, the power systems and traffic systems are more and more interdependent on each other. To analysis this interdependence more concisely, an optimal traffic power flow problem is formulated with the help of alternating current (AC) optimal power flow and vehicle routing problem (VPR). These two problems are integrated into an unified time-space network (TSN), as a mixed integer programming problem. To solve the meso-scale level problems with multiple oriented destination pairs, the random permuted alternating direction method of multipliers is adopted to solve the formulated problem distributed. The case study is performed on the modified IEEE-30 and Sioux fall networks, and the results verify the effectiveness of the proposed scheme.

Keywords: Power System, Electric Vehicle, Vehicle Routine Problem, Time-Space Network.

P1202

Modeling and Mitigating LED Nonlinearity using Nonlinear ARX model with Wavelet Networks

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In this paper, a nonlinear autoregressive exogenous (NARX) model with a wavelet network is applied to model and compensate the nonlinearity of the LED in Visible Light Communications (VLC). The NARX model shows the ability to accurately describe the response of the LED. PAM-4 signal with a symbol rate of 5 Msym/s is used to demonstrate the performance of the NARX adaptive compensator. The eyediagrams show that this compensator can substantially improve the distorted signal. The complexity of the NARX adaptive compensator is relatively low, with only 15 units. This also facilitates the adaptive parameters updating process due to the small number of parameters in the NARX adaptive compensator.

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Backstepping-Based Adaptive Control for Uncertain Fractional-Order Nonlinear Systems

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In this paper, we aim to solve the output tracking problem for a class of uncertain single-input-single-output (SISO) commensurate fractional-order uncertain nonlinear systems in the presence of bounded disturbances. To this end, an adaptive backstepping smooth control strategy is proposed, with two adaptive laws respectively estimating unknown system uncertainties and the upper bound of disturbances. Theoretical analysis is provided by employing fractional directed Lyapunov method to show that all the closed-loop signals are uniformly ultimately bounded. Subsequently, an adaptive smooth control scheme for second-order fractional systems is further proposed which guarantees asymptotically output tracking. Simulation studies are presented to verify the effectiveness of the proposed control methods.

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Power Flow Flexible Operation Analysis for Series-Parallel Architecture Region Energy Router

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Energy router (ER) is a core equipment in the energy internet and an important symbol of the next generation smart grid. Due to the limitation of topology architecture, the traditional series architecture region ER (SA-RER) has the disadvantages of limited loading capacity and inability of flexible operation for the reactive power. To this end, this paper intends to build a new type of region ER with the series and parallel architecture (SPA-RER), which breaks the double limits of the SA-RER's 100% energy transmission and reactive power rigid operation. The power flow flexible operation mechanism of SPA-RER is analyzed, the calculation methods of power flow in different operation modes are given, so that its operation law is clarified. By controlling the degree-of-freedoms of active and reactive power, SPA-RER can flexibly match the active power between the AC grid and the DC bus as well as the reactive power between the series and parallel converters. As a result, without increasing the system capacity and AC input power distribution, the transmission targets of 200% active power and 120% reactive power can be achieved, which provides novel design ideas and solutions for ERs to achieve high-power energy flexible transmission.

Keywords: Energy Internet, Energy Router, Power Flow, Flexible Operation, Degree-Of-Freedom.

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Structural Design of A Novel Electromagnetic Driven Spherical Motion Generator

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This paper introduces the structural design of a novel spherical motion generator. The electromagnetic drive mode of a spherical motor is applied to the three-degree-off-reedom (3-DOF) spherical parallel manipulator, in order to solve the problem of motion error caused by the transmission device and motor following in the traditional spherical parallel manipulator. A brief explanation of the electromagnetic drive working principle is mentioned. And the modeling of magnetic field and the optimization of magnetic field distribution are also discussed. In the future work, we will also optimize the magnetic field distribution of the platform and study the high-precision control strategy.

Keywords: Spherical Motion Generator, Electromagnetic Driven, Structural Design.

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A Novel Method of Open Circuit Voltage Reconstruction for $LiFePO_4$ Battery based on Incremental Capacity Analysis

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The inconsistencies of capacity and SOC make series-connected cells unable to be completely charged or discharged, which severely restrict the performance of the pack. In this case, the complete open circuit voltage (OCV) curve of cells will not be available, which will affect the accurate estimation of capacity and SOC. Therefore, how to reconstruct the OCV curve of cells without disassembling the pack is of great significance for the BMS to accurately estimate the cell state information and improve the stable operation of the energy storage system. In this paper, a new method to reconstruct OCV of $LiFePO_4$ battery based on incremental capacity analysis (ICA) is proposed. Feature points closely related to battery aging are extracted based on ICA obtained from OCV curve. By using voltage curve transformation, the optimal transformation coefficients are calculated. Finally, the reconstructed OCV curve segments will be obtained by transforming the OCV curve of other cells in the pack. To verify the method, experiments are conducted with cells connected in series, and the results show that the maximum error of the reconstructed OCV curve does not exceed 2.5%.

Keywords: $LiFePO_4$ Battery, OCV, Curve Reconstruction.

Session	TT01 Artificial Intelligence (1)
Date	1 – 14 August 2021

P1031

Cherrypick: Solving the Steiner Tree Problem in Graphs using Deep Reinforcement Learning

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Steiner tree problem (STP) in graphs aims to find a tree of minimum weight in the graph that connects a given set of vertices. It is a classic NP-hard combinatorial optimization problem and has many applications in real world. Many approximate algorithms have been developed for STP, but they suffer from high computational complexity and weak worst-case solution guarantees, respectively. Heuristic algorithms are also developed. But each of them requires application domain knowledge to design and is only suitable for specific scenarios. In this paper, we design a novel framework Cherrypick based on novel graph embedding and deep reinforcement learning to tackle the STP. Given an STP instance, Cherrypick uses this embedding to encode its path-related information and sends the encoded graph to a deep reinforcement learning component based on deep Q network (DQN) to find solutions. We implement the Cherrypick and demonstrate its efficacy and efficiency with extensive experiments using real-world and synthetic datasets.

Keywords: Steiner Tree Problem, Graph Embedding, Reinforcement Learning.

P1078

Research on Image Classification Algorithm Based on DenseNet for Small Sample in Industrial Field

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Image classification is an important branch in the field of computer vision and it has a wide range of application scene. The level of automation has been greatly improved by image classification technology in the field of industry, effectively reducing the complexity of many tasks.

However, traditional image classification methods cannot adapt to the complex and changeable environment in practical application of the industrial field. The recognition accuracy is low and the maintenance of these industrial systems is difficult. Therefore, an improved DenseNet network model called small kernel densely convolutional neural network (SK-DCNN) is proposed to improve the performance of small sample image classification in the industrial field. Small convolution kernel in SK-DCNN can fully and effectively extract more subtle features in the image. The dense connection method of dense blocks further improves the reuse of features on the basis of DenseNet. Using a small amount of data to train the model can obtain high classification accuracy. The experimental results of the article show that SK-DCNN achieves good performance (about 96.9%), which is about 4% higher than the accuracy of DenseNet. The comparative analysis with other typical neural network models also shows that the algorithm proposed in this paper has better classification effect in complex small sample images.

Keywords: Image Classification, DenseNet, Small Sample, Convolutional Neural Network, Industrial Field.

P1099

Interface Identification of Automatic Verification System Based on Deep Learning

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Automatic verification system is the future trend in the metrological verification field. However, it is still a problem waiting to be solved that the system can automatically recognize instrument interfaces with different models and can record data. Based on YOLOv3 deep learning algorithm, this paper shoots and makes instrument interface data sets independently. In addition, the network model training is conducted under the PaddlePaddle framework. On the LabVIEW platform, the encapsulation model has designed that the automatic verification system instrument interface recognition module is used by automatic verification system. Through real machine tests, the instrument interface recognition module can effectively identify the instrument interface to be checked and can identify multiple data windows, indicating that the method can meet the tasks of instrument interface recognition in the automatic verification system.

Keywords: Deep Learning, YOLOv3, Object Detection, Automatic Verification System, Metrological Verification.

P1120

Real-time Human Activity Classification From Radar With CNN-LSTM Network

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Millimeter-wave radar is becoming an attractive solution to human activity classification for smart home monitoring, with radar's robustness and privacy-less advantage. Especially, the low signal-noise-ratio and real time requirement are meaningful to do further study on. In this paper, we propose a two-stream framework to detect human activity and classify the activity sequence simultaneously. We also fuse the range, velocity and spatial angle of target to improve the accuracy of classification. We gathered a human activity data set, containing 6 activities over 6 persons. The result of experiment shows that the detection-classification system achieves an average accuracy higher than 90% for classifier within 1 second, respectively.

Keywords: Millimeter-Wave Radar, Human Activity, Real Time, Two-Stream, CNN, LSTM.

P1294

Power Grid Fault Diagnosis Based on SSAE and CNN

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The fault of power grid will cause serious personal safety problems and economic losses. It is very important to diagnose the power grid fault accurately and quickly. In order to improve the fault diagnosis accuracy for hybrid AC-DC power grid, this paper proposes a stacked sparse autoencoderconvolutional neural network method.

The paper uses stacked sparse autoencoder (SSAE) to reduce the dimensionality of high dimensional data sets, and then uses convolutional neural network (CNN) to extracts data features to diagnose different line faults and different types of faults in the power grid. Finally, the effectiveness of the proposed method is validated by MATLAB simulation, and shows that the proposed method has a high accuracy to distinguish different faults.

Keywords: Deep Learning, Fault Diagnosis, Stacked Sparse Autoencoder, Convolutional Neural Network.

P1374

Research on Inversion Algorithm of Aerosol Extinction Coefficient Based on Elman Neural Network

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Lidar, as an active remote sensing detection instrument, has become a powerful tool for atmospheric aerosol detection research. The extinction coefficient could be inverted by the lidar equation. However, the traditional method required many assumptions and complicated calculations when inverting the aerosol extinction coefficient, which greatly limited the accuracy and efficiency of the inversion. In this article, a method for predicting the aerosol extinction coefficient using Elman neural network was proposed. The neural network model was continuously trained to directly predict the aerosol extinction coefficient from the lidar echo signal, which effectively improved the aerosol extinction of the coefficient inversion efficiency. The experimental results show that the method with high prediction accuracy and the prediction effect was improved. The wide application prospect and practical value were possessed by the method and it provided a new idea for the inversion of extinction coefficient.

Keywords: Extinction Coefficient, Elman Neural Network, Lidar, Aerosol.

P1002

MFA: Multi-level Feature Aggregation for Video Recognition

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Deep convolutional neural networks (CNNs) are successful in self-extracting features for video object detection. The deep features and shallow features extracted from CNN are different. The shallow features have low-level semantic information, while the deep features contain high-level semantic information. In this paper, we propose an effective feature fusion method: Multi-level feature aggregation (MFA), which connects the output layer of each stage to the input layer of other stages and combines the output of each stage at the last layer of the network. This architecture can effectively combine shallow features and deep features to enhance the ability of expressing features and recognition accuracy. MFA is a flexible and end-to-end network. In addition, our experiments prove that MFA achieves significant accuracy on DET and VID datasets on object detection, and our method achieves mAP on DET and VID.

Keywords: Video Object Detection, Deep Convolutional Neural Networks, Feature Aggregation.

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P1042

Short-Term Wind Speed Prediction Based on Data Preprocessing with Discrete Wavelet Transform-mutual Information and Neural Network

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Accurate wind speed prediction can effectively reduce the wind abandon rate, thus reducing the operation cost of power system. However, the prediction of wind speed by a single algorithm may lead to incomplete extraction of relevant features and the possibility that irrelevant variables may cover up important variables.

Therefore, this paper proposes a short-term wind speed prediction method based on the combination of wind speed data preprocessing and neural network. The method of combining discrete wavelet transform with mutual information is used to mine the wind speed data, and then the intelligent algorithm is used to optimize the neural network to further improve the prediction accuracy. Firstly, the trend sequence and noise sequence are obtained by discrete wavelet transform. Then, considering the interaction between input variables and frequency components, the mutual information method is adopted to screen high and low frequency sequences. After screening, the variables with high correlation are selected as the input of the prediction model. Finally, the BP neural network based on Yin-Yang pair optimization algorithm is used to predict the wind speed. The results show that the proposed method has higher prediction accuracy than existing prediction methods.

Keywords: Mutual information, Discrete wavelet transform, Yin-Yang pair optimization, BP neural network, Wind speed forecasting.

P1044

Detection of Driver Fatigue State using Deep Neural Network

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Image-based driver fatigue detection remains a challenging problem due to occlusion of face, the variation of head poses and illuminations. This paper implements an effectual technique for investigating the driver's fatigue state by using infrared image of an eye in the open or closed condition. In this method we use the deep learning technique to monitor the change, i.e., open and closed conditions of eye state. We integrate ResNet and depthwise convolution network together and use as the core of the structure of the network to perform face and facial landmark detection tasks. After acquiring the eye region, we perform the eye state identification task by using its coordinates of feature points. To determine fatigue, we use PERCLOS method and the results confirm accuracy and effectiveness of the algorithm by comparing with other existing methods.

We can reach an accuracy of 97.2% and the average time is 31.20 milliseconds, represent that this driver monitoring inference system has significant importance for both the traffic and driver's safety.

Keywords: Driver Fatigue Detection, Deep Neural Network, ResNet, Depthwise Convolution Network, PERCLOS.

P1047

Real-time Detection of Pantograph Using Improved CenterNet

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With the rapid development of China's railway industry, inspection technology for safe railway operations has become very overwhelming. The pantograph is one of the important components of the high-speed rail power supply system. It is therefore very necessary to accurately monitor the state of the pantograph in real time. In this paper, a fast and accurate pantograph detection model based on improved CenterNet is presented. By replacing the original backbone with lightweight MobileNet and integrating with feature pyramid networks (FPN), our model can achieve the best speed-accuracy trade-off in real-time detection of pantograph.

Keywords: CenterNet, FPN, MobileNet, Pantograph, Real-time Detection.

P1048

Multi objective flower pollination algorithm based on non-dominated sorting

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This paper mainly studies the implementation of flower pollination algorithm in multi-objective optimization problems, flower pollination algorithm mostly uses the way of setting weight to transform multi-objective optimization into single objective optimization, but the setting of weight coefficient mostly depends on the experience of experts, it makes the whole algorithm more subjective, the final performance of the algorithm largely depends on the research level of researchers.

This paper proposes a multi-objective flower pollination algorithm based on the traditional flower pollination algorithm, which uses non-dominated sorting to find the elite solution of each generation solution set, and then finds the Pareto optimal solution according to the crowding distance. The algorithm is compared with other three kinds of multi-objective optimization algorithms. The results show that multi objective flower pollination algorithm based on non-dominated sorting(NSFPA) has a good effect on solving multi-objective problems.

Keywords: Flower Pollination Algorithm, Multi-Objective, Non-dominated Sorting, Crowding Distance.

P1265

Regional Traffic Flow Prediction on Multiple Spatial Distributed Toll Gate in a City Cycle

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It is hard to predict the regional traffic flow including hundreds of predicted points in a city cycle. Highly nonlinearity and complexity are the characteristics of these spatial distributed dynamic values of traffic flow. In this paper, the spatial-temporal correlation of traffic data is studied and combined with deep learning approaches. A novel and improved network structure taken the advantages of both temporal convolutional network (TCN) and graph convolutional network (GCN) is presented, termed as temporal convolutional network spatial-temporal graph convolutional networks (TCN-STGCN). Meanwhile, the original data of 186 toll stations in Shaanxi Province is obtained as a data set through the flow calculation method. Furthermore, the existing typical deep learning models are selected to compare with the improved models to predict traffic flow. The results show that the improved model can make accurate predictions in as fast as 16 minutes, and the effect of long-term prediction (45min) is improved by 17.922% compared with the model before the improvement, which provides the possibility for vehicle navigation systems and intelligent traffic control.

Keywords: TCN-STGCN, Freeway, Traffic Flow Prediction, Toll Data.

P1309

Synthesised Optimal Control for a Robotic Group by Complete Binary Genetic Programming

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The paper continues the study of symbolic regression methods for control learning. The optimal control problem with phase constraints for a group of robots is considered. To solve the problem, the method of synthesized optimal control is used. At the first stage the stabilization problem is solved for each robot. Using a new hybrid evolutionary algorithm, built on the basis of the genetic algorithm, the particle swarm optimization and the gray wolf optimizer, stable equilibrium points are found. Next, the original optimization problem by piece-wise linear approximation of the equilibrium points is solved. In contrast to the known methods for solving the synthesis problem, the control learning by the complete binary genetic programming is used. The advantage of this approach is that the resulting control is realizable on board of mobile robots. Simulation is given for a group of two mobile robots.

Keywords: Machine Learning, Optimal Control, Robotic Group, Symbolic Regression.

P1334

Text Classification Model Based on BERT-Capsule with Integrated Deep Learning

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Current text classification methods based on traditional capsule network models cannot properly reflect the importance of different words in a text sequence, and cannot effectively extract multi-level semantic features in text. To address the shortcomings of the traditional capsule network model, a text classification model based on BERT-Capsule integrated deep learning is proposed, which takes advantage of BERT's bi-directional encoding of text features and the improved routing mechanism of the capsule network as the basis.

The model not only extracts the contexts information of text more comprehensively, but also learns the local word features and global semantic features of text to ensure the stability of the result classification. Finally, the BERT model before integration, the capsule network model and the BERT-Capsule model after integration are evaluated by instances on IMDB, AG News, and Reuters-21578 datasets. The experimental results demonstrate that the BERT-Capsule integrated model outperforms the BERT model before integration and the capsule network model in terms of accuracy of text classification, and the generalization error is lower, and the model can be used for text classification.

Keywords: Text classification, BERT, Capsule Network, Dynamic routing.

Session	TT03 Control and Systems (1)
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P1025

Research on H_∞ Robust Frequency Control Strategy with Temperature Control Load

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To solve the problem of supply and demand imbalance caused by the fluctuation of renewable energy in the power system, This paper is based on the frequency modulation model of temperature-controlled load (TCL) participating in power system, and this paper designs a H_∞ robust frequency state feedback controller based on linear matrix inequality (LMI) for load frequency control (LFC) of multi area interconnection. The simulation results show that the proposed control method can effectively improve the robustness of the frequency and stability of the system under disturbance and uncertainty conditions, and improve the control effect.

Keywords: Temperature Control Load, Frequency Control, Demand Response, State Feedback, Linear Matrix Inequality.

P1041

Preview Control of Semi-Active Suspension with Adjustable Damping Based on Machine Vision

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In order to improve the ride comfort of vehicles equipped with damping continuously adjustable semi-active suspension on bad road, this paper presents a preview control model of semi-active suspension based on camera road condition recognition. In this paper, YOLO v2 is used to detect the speed bump, and the improved Skyhook control strategy is used to adjust the vertical damping force of the suspension in real time, so as to realize the preview control of the semi-active suspension. The simulation result shows that the identification method based on YOLO v2 algorithm can accurately detect the road speed bump. The improved Skyhook control strategy can effectively suppress the vertical vibration. Combined with machine vision, the semi-active suspension preview control can adjust the suspension damping ahead and effectively improve the ride comfort of the vehicle.

Keywords: Semi-active Suspension, Improved Skyhook Control, YOLO v2, Preview Control.

P1049

Thermostatically Controlled Loads Participating in Microgrid Regulation Strategy Based on Model Prediction

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In order to solve the problems of slow response speed, poor reliability in microgrid frequency regulation strategy, this paper presents a frequency regulation method of thermostatically controlled loads(TCL) participating in the microgrid based on model prediction. This method uses the area control error as the input of the model predictive controller, thermostatically controlled loads power change and the generator power change as the output. It makes full use of the frequency modulation potential of the temperature-controlled load, and through demand-side management, auxiliary generator sets improve the dynamic frequency modulation performance of the power grid. Through simulation experiments, the effectiveness of the proposed microgrid frequency regulation strategy is verified. Compared with the traditional frequency modulation method, this method helps reduce the system overshoot, speed up the response speed, and enhance the stability of the system.

Keywords: Model Predictive Control(MPC), Area Control Error(ACE), Thermostatically Controlled Loads, Demand-side Management(DSM), Microgrid

P1053

Study on Control Strategy of Wind Farm Combined with Energy Storage System

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This paper presents a wind storage system composed of permanent magnet synchronous generator, Vienna rectifier, battery and three level bidirectional DC-DC. The motivation for this topology is to make the system more reliable, power efficient, cost effective and simple to control. In the control of the wind turbine (WT), proposes a speed loop backstepping control strategy based on Lyapunov stability in the topology of permanent magnet synchronous generator (PMSG) - VIENNA rectifier. Energy storage system (ESS) adopts three-level bidirectional DC-DC converter based on constant power control. Through the MATLAB/Simulink, it is found that that the backstepping control could quickly track the rotation speed at the maximum power point (MPP) with stable waveform and small fluctuation range, the grid-connected inverter can output stably, and using simulation results validate the performance of proposed topology.

Keywords: PMSG, VIENNA Rectifier, Three-Level, Backstepping Control.

P1073

A New Designed Intelligent Weelchair with Elevating Lazyback

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As a typical representative of service robots for the elderly and the disabled, intelligent wheelchair have strong environmental adaptability, safe and stable motion performance, and intelligent interaction methods. They are an indispensable tool in social rehabilitation projects. For ordinary wheelchairs, most of them allow the rider to sit down slowly, but for those riders who have a back disease or need assistance to sit down, ordinary wheelchairs are not convenient to ride. Therefore, this article aims to improve the portability of wheelchairs for people with back problems. We propose a novel wheelchair based on the elevating lazyback, a new structure that can adjust lazyback angle quickly and flexibly. Different with the traditional wheelchair, the rider has the ability to get into the wheelchair from bed and sofa without others helped. we carry out the modeling and simulation of a new structure with the help of two kind of software, i.e. the MATLAB and the ANSYS. The results show that the proposed wheelchair has a good kinematic performance and well-feasibility, which means that the wheelchair can be used in the daily life. These simulated results will be significant for the development of intelligent wheelchair.

Keywords: Intelligent Wheelchair, Elevating, MATLAB, ANSYS, Ergonomics.

P1075

Adhesion Control of High Speed Train Based on Vehicle-control System

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The wheel-rail adhesion was closely related to the safe operation of high-speed trains. To make full use of the adhesion force between wheel and rail, an adhesion control method based on vehicle-controlled was proposed. The method sets the optimal torque searching vehicle to detect the wheel-rail adhesion according to the obtained creep speed and its acceleration. The optimal torque was quickly calculated which was suitable for running under the current rail surface condition and then transmitted to the other motor vehicles. The control units of motor vehicles made reasonable torque adjustment for each vehicle. Finally, a simulation model of the traction drive adhesion control system based on the CRH2 high-speed train was built using MATLAB/Simulink. The simulation results verified the feasibility of the method.

Keywords: High-Speed Trains, Vehicle-Controlled, Optimal Torque Searching and Transmitting, Adhesion Control Component.

P1093

Development of Control System for a High-Speed Permanent-Magnet BLDCM

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High speed BLDCM has the advantages of high power density, high efficiency, high speed range and so on, but the traditional BLDCM uses position sensor to obtain the rotor position information, which limits its application. In recent years, the control of BLDCM without position sensor has become a research hotspot. In this paper, a control system for a high-speed permanent-magnet BLDCM is presented. The control system consists of control module, 232 communication, inverter module, PWM driver, detection circuit and RC filter Circuit. Also, software based on ARM is designed to realize the fuctions. Experimental studies are carried out on the prototype to validate stability and reliability of the control system.

Keywords: Control System, Hardware Design, Permanent-Magnet BLDCM, Back-EMF Zero-Crossing Detection.

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P1159

Fault Tolerant Control Strategy Based on Model Predictive Control and Unscented Kalman Filter for Permanent Magnet Synchronous Motor

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Permanent Magnet Synchronous Motors (PMSMs) are now extensively used in many critical applications. There is an increasing need for the motor and control system to have fault tolerant capabilities. This paper presents a fault tolerant control strategy to operate the PMSM during inter-turn fault conditions. The proposed technique combines the Model Predictive Control (MPC) for the speed and current control loops, and an almost error-free Unscented Kalman Filter (UKF) to estimate the PMSM inter-turn fault ratio. The PMSM statespace model for healthy and faulty conditions will be presented. Also, the equations and the remedial action of the MPC and UKF are provided in detail. The proposed algorithm is applied to PMSM model as a case study with a range of simulation analysis and discussion of results.

Keywords: Fault Tolerant, Fault Diagnosis, Model Predictive Control, Unscented Kalman Filter, PMSM.

P1228

Disturbance Observer Based Adaptive Fuzzy Sliding Mode Controller for Cable Arrangement System

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To improve the adaptability of the cable arrangement mechanism of an electrical winch and ensure the neat arrangement of the cable on the drum with different disturbances and uncertainties, a nonlinear speed tracking controller AFSMC-DBO based on adaptive fuzzy sliding mode control (AFSMC) and disturbance observer (DBO) is proposed in this paper. The stability and convergence of the whole system are proved by the Lyapunov stability theory and verified by simulation experiments. Simulation results show that the AFSMC-DBO controller has high tracking performance and strong robustness against external disturbance and system uncertainty.

Keywords: Disturbance Observer, Adaptive Control, Fuzzy Control, Sliding Mode Control, Cable Arrangement System.

P1270

Optimal Vibration Analysis for A Combustion Motor

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Combustion motors have quite important uses in Peru due to capacity of energy that is achieved to solve multiple tasks, such as for example public transport, mining and factories. However, a big disadvantage is given owing to pollution that is produced through them. Therefore, there are many proposal solutions as for example, optimal control over physical variables, which have information of consumed fuel. Nevertheless, it gets complications in interesting (but longer) algorithms as strategies. That is the reason, why in this research is proposed a mathematical procedure that is correlated with faster and robust sensors/actuators according to achieve an enhancement performance over the efficiency of combustion motors.

Keywords: Optimization, Combustion Motors, Faster and Robust Sensors/Actuators based in Nanostructures.

P1298

Adaptive Sliding Mode Control for Steer-by-Wire Road Vehicle Systems based on Dynamic Parameter Estimation

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In this paper, a novel adaptive sliding mode controller (ASMC) for the steer-by-wire (SbW) system on road vehicles is proposed. It is shown that a new frequency domain identification method is able to estimate cornering stiffness effectively in the frequency domain with sinusoidal steering inputs. An adaptive sliding mode controller can then be designed reasonably. Unlike many existing sliding mode control (SMC) schemes, the proposed ASMC not only guarantees the zero-error convergence, but also has fast adaptation and strong robustness with respect to frequent changes of road conditions based on the designed estimator. Simulation results have confirmed the advantages and effectiveness of the proposed ASMC from comparing with the traditional SMC.

Keywords: Adaptive Sliding Mode Controller, Frequency Domain Estimation, Fast Adaptation.

P1310

Trajectory Control in Non-Minimum Phase Plants

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Non-minimum phase plants are always difficult to control. Recently, the so-called Linear Algebra Based Control Design methodology has been used for trajectory control of linear and nonlinear plants, being initially limited to minimum phase plants. In this work, the approach is extended to deal with unstable zero dynamics plants. First, the case of linear plants is analyzed, considering the appearance of a non minimum phase zero. A solution is proposed to deal with the zero in the positive real axis, requiring a reference signal known in advance. Then, the approach is applied to nonlinear plants where the unstable zero dynamics is determined by a single parameter in the plant model. Simulations are included to illustrate the procedure.

Keywords: Linear Algebra Based Control, Zero Dynamics, Nonminimum Phase Plants.

P1318

Contour Error Compensation based on Feed Rate Adjustment

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To improve the performance of computer numerical control (CNC) machining, especially for large-curvature trajectories, this paper presents a contour error compensation algorithm based on reference trajectory modification. In order to estimate the contour error accurately and efficiently, a contour error estimation model is established. The reference trajectory is modified on the basis of the estimated contour error and partitioned into different segments, which adopt different feed rates according to a corner detection algorithm. The effectiveness of this contour error compensation algorithm is verified by experiments on a CNC machine tool.

P1324

Remote Current and Voltage Monitoring System Based on Cloud Storage and Wireless Communication Technology

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This paper introduces the remote current and voltage monitoring system based on cloud storage and 5G wireless communication technology, including acquisition module, data processing module, Ethernet module and terminal; Acquisition module acquisition device of three phase current and three-phase voltage being measured, by matching the operational amplifier to convert signals AD input circuit, then the measured data of voltage and current fast Fourier transform, then the main frequency component amplitude and phase of signal transmission to the Ethernet module, realize the transmission of high compression test data. The data of voltage and current can be read and recorded by accessing Ethernet module through terminal and Internet of Things platform. Thus, a remote automatic monitoring system for voltage and current of electromechanical equipment and their operating conditions is proposed.

Keywords: Data Intelligent Compression, AFFT, 5G, Remote Monitoring.

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P1330

Hierarchical Voltage/Var Optimization Control of a Wind Farm

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With the rapid development of wind power generation technology, large-scale wind farms are connected to the power grid, which makes the voltage stability of the system vulnerable to the multi time scale characteristics of wind farms. Therefore, the voltage/var control strategies have received extensive attention. This paper proposes a hierarchical voltage/var optimization control strategy of wind farms based on the multitime scale characteristics of voltage/var control devices in the wind farm. Compared with the traditional voltage/var control strategy, this strategy coordinates different control stages in multiple time ranges. In this way, different voltage/var control devices can cooperate to realize the voltage/var optimization control of the wind farm. The performance of the proposed strategy is verified through a wind farm model of doubly-fed induction generator type in MATLAB / Simulink. The simulation results show that this strategy can effectively reduce the power loss and voltage deviation.

Keywords: Wind Farms, Voltage/Var Control, Optimization Control, Multiple Time Scales.

P1356

Research on Trigonometric Velocity Scheduling Algorithm of Five-axis CNC System Based on Constraints

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A novel algorithm is addressed for acceleration and deceleration planning of five-axis CNC (Computer Numerical Control) System, aiming at vibration of CNC caused by the velocity and acceleration of rotation axis beyond the limit range of the machine tool. The algorithm uses trigonometric functions to plan the velocity, acceleration and jerk, and carries on the kinematic constraints of the translational axis and the rotation axis. Experiment shows that this is a simple and effective algorithm to achieve continuous velocity, acceleration and jerk within the limited range of five-axis CNC System, thereby reducing machine vibration and achieving high speed, high efficiency and high precision machining.

Keywords: Trigonometric Velocity Scheduling, Translational Axis , Rotation Axis, Constraints, Five-Axis.

P1398

Prescribed Performance Bound-based AdaptiveTracking Control of a Mobile Robot with Visibility Constraints

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This paper mainly investigates the tracking control problem for a mobile robot with visibility constraints. The dynamics of a two-wheeled nonholonomic mobile robot is firstly established. By considering the objective of tracking a movingtarget with unknown velocities, an adaptive controller is designedby utilizing backstepping technique. Furthermore, the prescribed performance bound (PPB) technique is adopted to guarantee that the moving target is always forced within the visible range of theon-board camera. Simulation results are provided to validate the theoretical results.

Keywords: Adaptive Control, Prescribed Performance bound, Nonholonomic Mobile Robot, Visibility Constraints.

P1403

Research on Sensorless Control of PMSM Based on Fuzzy Sliding Mode Observer

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In the sensorless control system of permanent magnet synchronous motor (PMSM), the feedback accuracy of rotor position and speed affects the dynamic performance of the system. The sliding mode observer (SMO) can be used to observe the rotor position and speed effectively. To reduce the chattering and improve the observation accuracy, the fuzzy control and SMO are combined first in the paper, and the fuzzy sliding mode gain is designed to be adaptively changed according to the system state. Then a low-pass filter (LPF) whose cut-off frequency is variable with speed is used to filter the extended electromotive force (EEMF) observed by the SMO. In this way, the improved SMO is more suitable for different operating states of the motor. Besides, the paper analyzes the superiority of the method over the conventional SMO theoretically. Finally, it is verified through simulation that the proposed control strategy without position sensor can effectively weaken the system chattering and improve the observation accuracy of rotor position and speed.

Keywords: Permanent Magnet Synchronous Motor(PMSM), Sensorless Control, Sliding Mode Observer(SMO), Adaptive Fuzzy Control.

P1057

Nonlinear-Extended-State-Observer-Based PD Position Control of Planar Motors

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To improve the ability of anti-interference and robustness of planar motors, this article proposed a proportional-derivative (PD) position control method using a nonlinear extended state observer (NESO). Firstly, the dynamic model of a planar motor is given. And then, the lumped disturbance of the planar motor system is observed by using a developed nonlinear extended state observer, in which the observer parameters are committed to ensuring the stability of the NESO. The observed disturbance is compensated to the output of the PD controller, to enhance the ability of disturbance suppression and robustness of the planar motor control system. Moreover, simulation results prove that the proposed method can effectively suppress the disturbance of the planar motor to achieve satisfactory control performance and verifies the effectiveness and feasibility.

Keywords: Nonlinear extended state observer, planar motor, lumped disturbance, and motion control.

P1076

Use the Harmony-SE Approach to Extend the Advantages of MBSE

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This paper introduces a case of UAV mission management system and uses the model-based system engineering (MBSE) method to model and analyze the case. Because many historical uses of SysML are concentrated in the early stages of the project life cycle, this paper uses the Harmony-SE method to extend the advantages of MBSE to the later stages of construction projects. In addition to obtaining visual models, this research method can also produce a series of deliverables that guide project construction. Not only reduces product maintenance costs and development cycles, but also facilitates communication with developers, making communication clearer and reducing ambiguity.

Keywords: UAV Mission Management System, MBSE, SysML, Life Cycle, Harmony-SE.

P1109

Robust Finite Non-Singular Terminal Synergetic Control for Second Order Nonlinear Systems Subject to Time-Varying Mismatched Disturbances

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This paper proposes a novel robust finite synergetic control approach for nonlinear systems subject to time-varying mismatched disturbances. Its main objective is to guarantee the finite-time convergence of the states while eliminating the singularity problem and providing a chattering-free response despite the disturbances. The controller is formulated based on a novel non-singular terminal sliding manifold and the disturbances are estimated using a nonlinear finite time disturbance observer. By estimating the values of the mismatched disturbances and uncertainties, a novel synergetic manifold is introduced which compensates for an estimate of the disturbances. This yields a robust Finite Non-singular Terminal Synergistic Control (FNTSC) that is capable of counteracting the effects of the time-varying mismatched disturbances. System stability is established using the Lyapunov stability theory. The effectiveness and performance of the proposed approach is assessed using a four-bar linkage mechanism as a study case. The obtained results confirmed the robustness, finite time convergence and chattering free dynamics of the proposed controller.

Keywords: Robust Synergetic Control, Mismatched Disturbance, Disturbance Observer, Lyapunov Stability Theory.

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P1205

Current Tracking Control of Switched Reluctance Machine with Low Dependence on Electromagnetic Characteristics

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In many cases, the closed-loop phase current control is indispensable for the operation of the switched reluctance machine (SRM). To achieve the compromise among the convenience, adaptability and accuracy, a phase current tracking control approach is proposed, which fully utilizes the robustness of the sliding mode theory.

According to the reference phase current from certain algorithm, the reference excitation voltage is obtained with the sliding mode controller, which just requires the unsaturated phase inductance of the SRM at the aligned rotor position. Furthermore, the excitation voltage is accurately supplied to the phase windings through a four-state pulse width modulation (PWM) scheme. The performances of the proposed control method are evaluated with detailed simulations and experiments under different operating conditions, and the comparisons with the commonly used hysteresis current control (HCC) method are carried out as well.

Keywords: Current Tracking, Four-State Pulse Width Modulation, Robustness, Sliding Mode Control, Switched Reluctance Machine, Unsaturated Phase Inductance.

P1263

An Improved Sensorless Control Scheme for PMSM with Online Parameter Estimation

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This paper proposes an improved sliding mode observer based on super-twisting algorithm (STA-SMO) for sensorless control scheme of permanent magnet synchronous motors. An α-β axis stator current observer is built according to the back electromotive force (EMF) model after the back EMF error signal is obtained. The chattering phenomenon inherent in the traditional STA-SMO is eliminated by restricting the equivalent disturbance term to a small range, the coefficient of observer can be kept constant with speed variations. Meanwhile, because the mismatch between actual and set resistance associated with stator temperature may lead to a large estimated error and even system instability, a parallel stator resistance online estimation scheme is presented based on modified SMO. The stability of the online stator resistance estimator is proved by Lyapunov function. Compared with the traditional STA-SMO, the improved STA-SMO not only improves the accuracy of rotor position observation, but also effectively avoids chattering. Finally, the effectiveness of the proposed improved sensorless control scheme is verified by computer simulation.

Keywords: Permanent Magnet Synchronous Motor (PMSM), Super-Twisting Algorithm (STA), Sensorless Control, Online Parameter Estimation.

P1277

A Novel Hybrid Energy Storage Integrated Traction Power Supply System and its Control Strategy for High-speed Railway

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In order to improve the regenerative braking energy (RBE) utilization, realize peak load shifting and reduce the negative sequence current in high-speed railway, a hybrid energy storage integrated traction power supply system (HESTPS) is presented in this article. The new power supply system is composed of a single traction transformer, a power flower conditioner (PFC) and the hybrid energy storage system (HESS), and the HESS is connected onto the dc link of the PFC. First, the working principle of the HESTPS is introduced, including the system working mode and the power flow distribution in each mode. Then, since the PFC and the HESS forms a multiport structure, an optimized control strategy is proposed to realize the coordination control of the system. Finally, a simulation is given to demonstrated the feasibility of the proposed topology and control strategy.

Keywords: Hybrid Energy Storage System, Peak Load Shifting, Regenerative Braking Energy, Negative Sequence.

P1282

Compensation Strategy Research of Co-Phase Traction Power Supply System With Vv Transformer Under Asymmetric Grid Voltage

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In the case of symmetrical grid voltage, the cophase traction power supply system (CTPSS) with traditional compensation strategy can effectively compensate the negative sequence current and reactive power. However, In the case of asymmetrical grid voltage, it is difficult to achieve compensation with traditional compensation strategy. This paper studied compensating strategy of CTPSS with Vv transformer under asymmetric grid voltage.

Firstly, the mathematical model of CTPSS under asymmetric grid voltage is established. Then, the effect of asymmetrical grid voltage on the characteristics of power flow controller (PFC) compensation is analyzed, and a more optimized compensation strategy is proposed. Finally, a simulation model is built to verify the correctness of the compensation strategy, and the results show that the compensation capacity can be saved up to 26.74%.

Keywords: Co-Phase Traction Power Supply System, Asymmetric Grid Voltage, Negative Sequence Current, Power Factor.

P1384

Development and Expansion of Management Software for New Automatic Hematology Analyzer Based on PC/Windows

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With the improvement of automation and intelligence, the status of medical examination equipment has greatly improved. The five-differential hematology analyzer adopts the master-slave architecture which is between the management machine and the control machine, the master and slaves conduct command transmission and data interaction through the communication interface. The control system has developed by DSP controller on the basis of the five-differential blood analyzer model, and the system structure and functions of the operation management software have been further developed based on PC/Windows. The communication module, data management module and inspection accuracy have been improved. The system architecture design of the operation management software to expand and manage multiple control machines has been further proposed, systematic maintenance plan has been proposed for the modification and unreasonable maintenance of the existing software during the development and maintenance process, and software related functions have been expanded by the system.

Keywords: Automatic Hematology Analyzer, Five Differential, PC/Windows, Operation Management, Humancomputer Interaction(HCI).

P1410

Fuzzy Fault Detection Observer Design for Head-Two-Arms-Trunk System

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This paper deals with the problem designing fault detection observer for H2AT model in restricted frequencydomain specifications. Both disturbances and fault frequencies are assumed to be known and reside in a middle-frequency range. Different from previous results, the H2AT model is represented in the N-TS fuzzy model. It allows separating the unmeasured premise variables (UPV) in the local nonlinear consequent which provides a more effective way to deal with the UPV. In order to guarantee the best robustness to disturbances and sensitivity to faults, the fault detection observer combines the $H_-/H\infty$ performances. The design conditions are obtained based on Differential Mean Value Theorem (DMVT) property. Simulation result are conducted to demonstrate the viability and validity of the presented method.

Keywords: Differential Mean Value Theorem(DMVT), Fault Detection(FD), Observer, Unmeasured Premise Variables, Restricted Frequency-Domain Specifications (RFDSs).

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P1065

Optimization of Particle Swarm based MPPT under Partial Shading Conditions in Photovoltaic Systems

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Maximum power point tracking (MPPT) is a vital and essential requirement for photovoltaic (PV) systems under normal irradiance and partial shading conditions (PSCs). Although, perturb and observe (P&O) algorithm does not map the global maximum power point (GMPP), whereas the algorithm for particle swarm optimization (PSO) tracks it efficiently. This paper explores the rapid determination of GMPP under PSCs using a proposed particle swarm optimization MPPT technique which operates in conjunction with a boost converter. To achieve this analysis, MATLAB/SIMIULINK is used.

The results of the simulation illustrate the high tracking performance of the proposed technique under various irradiance patterns. Finally, the PSO is contrasted with the P&O algorithm to assess its effectiveness in tracking GMPP.

Keywords: Boost Converter, Maximum Power Point Tracking (MPPT), Particle Swarm Optimization (PSO), Perturb and Observe (P&O), Photovoltaic System.

P1102

Design and Implementation of a Low-Speed Wind Tunnel System

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Wind tunnel is one of the most important experimental equipment for aerodynamics researches, and most aerodynamic products also need to be tested in wind tunnel before applied in daily life. Most universities and research institutions are actively building wind tunnel laboratories to promote the research of related disciplines. Because of the important position of the wind tunnel system in the field of aerodynamics, many researchers have devoted themselves to wind tunnel design, and modern wind tunnel is developing towards high precision, intelligence, and high reliability. After the investigation of several existing wind tunnel laboratories, this paper designs a low-speed wind tunnel system, which is low cost, high integration, easy to use and maintain, and it can meet the needs of most basic aerodynamics researches.

Keywords: Wind Tunnel, Aerodynamics, Measurement And Control, System Design.

P1139

Radial Electromagnetic Force Analysis of Rotary Transformer Based on Inductive Energy Transmission

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Different from the traditional transformer, the rotary transformer proposed by authors has a rotary secondary winding which was called rotor. In the transformer, the vibration noise sources were more complex and electromagnetic vibration noise is particularly prominent. Because of the special structure, the radial electromagnetic force inside the transformer was much larger than the tangential electromagnetic force, which is the main factor affecting the electromagnetic vibration noise. The effect of the air gap lengths and air eccentricity on the radial electromagnetic force density of the rotary transformer was investigated on the finite element model and suggestions were given for optimum design.

Keywords: Rotary Transformer, Radial Electromagnetic Force Analysis, Air Gap Eccentricity.

P1161

Optimal Configuration of Concentrating Solar Power and Energy Storage System in 100% Renewable Energy Systems

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High proportion of variable renewable energy has caused increasing peak shaving pressure and more flexibility demands in 100% renewable energy systems. Concentrating solar power (CSP) and energy storage system (ESS) are competitive flexibility resources to solve the problems. This paper constructs an optimal configuration model for CSP and ESS in multi-energy power systems. The model considers the investment cost and operation cost in typical scenarios. Characteristics of different power sources are modeled and linearization method is applied to obtain a mixed integer linear programming (MILP) formulation. A case study based on real data shows that power systems benefit from the complementarity and coordination of CSP and ESS with other power sources. The configuration results are significantly affected by the penetration rate of variable renewable energy (VRE).

Keywords: Renewable Energy, Concentrated Solar Power, Energy Storage System, Optimal Configuration.

P1212

Research on Wireless Heating Device for Power 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. The internal heating method has become the first choice for preheating lithium-ion batteries. However, most of the existing internal heating devices are wired heating, which has disadvantages such as easy leakage, contact loss, and mismatch of plugs and sockets. In order to solve this problem, this paper proposes an AC heating device for automobile interior based on wireless power transmission. The lithium-ion battery is heated while the primary and secondary sides are separated by an air gap, and the heating speed can be adjusted online by controlling the output voltage. This paper analyzes the heating topology, and establishes a low-temperature heating experiment platform for lithium-ion batteries, which proves the feasibility and effectiveness of the scheme. Experimental result shows that the heating device only used 1100s to increase the lithium-ion battery from $-15°C$ to $5°C$.

Keywords: Lithium-Ion Battery, Internal Heating, Wireless Power Transmission, Low Temperature.

P1231

IIoT-enabled and Data-driven Sustainability Evaluation Framework for Textile Supply Chain

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Global ecolabelling scheme for consumer products could be beneficial to the world by increasing the public awareness about the environmental impact that might be caused by the manufacturing production along the supply chain activities, i.e., carbon footprint emission. By putting the conventional life cycle assessment (LCA) in tandem with the latest Industrial Internet-of-Things (IIoT) technologies, heterogeneous input and output data sources can be accumulated in real-time manner, towards a data-driven sustainability metric evaluation to produce the ecolabels to promote the eco-friendly consumer products in supply chain. In this paper, we present a high-level technical overview architecture to showcase how we utilize the IIoT technologies to enhance the sustainability evaluation metric along textile supply chain. The input and output data collection along all stages in the textile supply chain thus can be qualified and quantified to yield a guideline for LCA practitioners.

Keywords: Sustainability, Internet-of-Things (IoT), Textile Supply Chain, Ecolabelling.

P1247

Rolling Optimal Dispatch Strategy of Prosumer Considering Grid-Connected Power Fluctuation Suppression and Energy Storage Degradation Cost

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Small-scale renewable energy sources (RESs) have transformed from traditional energy consumers into energy prosumers. However, the problem of grid-connected power fluctuation deteriorated by rooftop photovoltaic has always been the main obstacle restricting the widespread application of distributed energy resources in demand-side users. In this paper, a rolling optimal dispatch strategy of energy prosumer, which considers the grid-connected power fluctuation suppression and the energy storage degradation cost, is developed to achieve economic and stable operation. The complementary characteristics of hybrid energy storage (HES) can not only play role in economic dispatch, but also smooth grid-connected power fluctuation. We build a mathematical model of the PV-HES-load system for the prosumer. Furthermore, the real-time power fluctuation suppression method with the trigger mechanism and based on the uncertainty interval is originally designed. Finally, to ensure the economic and stable operation of the system, a rolling optimal dispatch strategy is proposed. Numerical results show that the designed dispatch strategy for the prosumer can effectively mitigate the grid-connected power fluctuation and reduce total operation cost.

Keywords: Renewable Energy Sources, Energy Management, Prosumer, Power Fluctuation Suppression, Hybrid Energy Storage.

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P1248

Research on Data Acquisition System of Six-Dimensional Force Sensor

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The existing six-dimensional force sensor system uses a PCI card, which is large in size and is not suitable for embedded control systems. This paper designs a six-dimensional force sensor data acquisition system suitable for embedded systems with low power consumption and small size. The overall framework is composed of sensors (Stewart sensor head), analog signal processing circuit (amplification, low-pass filtering, anti-aliasing filtering), AD acquisition, power supply unit, data communication, data filtering processing, etc., completing the sixdimensional the software, hardware and algorithm design of force sensor data acquisition system.

Keywords: Six-Dimensional Force Sensor, Data Acquisition, Embedded System.

P1266

A Cooling Capacity Distribution Method For Liquid Cooling Cycle Based on Co-Simulation and Optimization of AMESim and modeFRONTIER

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The flow distribution of each branch of the aircraft's airborne liquid cooling cycle is a key issue to ensure refrigeration performance and improve energy utilization. Due to the correlation of multiple factors, the existing airborne liquid cooling cycle flow distribution method cannot achieve accurate flow distribution result.

This paper takes the maximum maximum temperature of all equipment as the optimization goal, and the joint simulation-optimization of the AMESim software and the modeFRONTIER platform is used to solve the optimization design problem of the flow distribution scheme. The result shows that compared with traditional design methods, the use of simulation-based optimization design methods can give full play to the advantages of AMESim software in simulation and performance index calculation and modeFRONTIER software in searching for optimal allocation schemes. It can reduce the maximum temperature of each branch device and effectively improve the cooling effect.

Keywords: Simulation Based Optimization, Liquid Cooling Cycle, Cooling Capacity Distribution, AMESim, modeFRONTIER.

P1353

Two-stage Distribution Network Reconfiguration Method Considering Load Type and Overload Rate

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In the operation of the distribution network, some network lines may be overloaded. In order to solve the problem, this paper proposes a distribution network reconfiguration model considering load type and network overload rate. First, a two-stage optimization model that takes the established load type into account and the purpose of this model is that transferring important loads into the line with a lower heavy load rate according to the load level. Then considering that the system topology will change with the load type, a new distribution network topology analysis algorithm is given in this paper. Finally, in order to improve the convergence performance, this paper choose two-stage optimization model solved by geneticgray-wolf algorithm. The simulation is carried out in the IEEE 33-Bus System. The results show that the model and algorithm have good results and convergence.

Keywords: Distribution Network, Reconfiguration, Topology Analysis, Genetic Algorithm (GA), Gray Wolf Optimizer.

P1072

The Influence of Different Factors on the Power-Generation Performance of Reverse Electrodialysis

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Reverse electrodialysis (RED) is a nonpolluting energy technology which can convert the salinity gradient energy into electricity. In this paper, the influence of different influencing factors on the power-generation performance is studied experimentally via linear sweep voltammetry (LSV) measurement based on the electrochemical workstation platform. The results show that the increase in the number of cell pairs makes the open circuit voltage and stack resistance raise while the maximum power density of RED stack decreases continuously. The optimal value of maximum power density is obtained when the cell pair number is 5. Regardless of whether the solution concentration ratio is constant or not, increasing the solution concentration will cause the stack resistance to reduce and the power density gradually rises. The highest maximum power density is found at 120-4 g/L. Finally, as the flow rate increases, the open circuit voltage remains unchanged and the stack resistance decreases, so correspondingly the maximum power density increases constantly. When the flow rate is 40 L/h, the RED system has the best power generation performance.

Keywords: Reverse Electrodialysis, Stack Configuration, Operating Condition, Power-Generation Performance.

P1104

Energy Trading Method of Distribution Network System with Multi-Microgrid Based on Stackelberg Game

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This paper proposes an economic optimal scheduling method of based on the stackelberg game theory to address the energy trading of distribution network(DN) with multi-microgrid "MMG". First, the optimal scheduling process is designed as a one-leader N-follower stackelberg game. The equilibrium solution of the game is solved by the mixed integer programming (MIP) and differential evolution (DE) algorithms. The distribution network operator (DNO) is taken as the leader, and the microgrid operator (MGO) is regarded as a follower, aiming at the minimum operation cost. DNO encourages MGO to participate in energy trading by setting internal transaction price; MGO makes energy storage and load decision in response to internal transaction price, and then affects the price strategy of DNO through the net load. Moreover, the power flow of distribution network is constrained to ensure its safe and stable operation. Finally, an example analysis of the improved IEEE 33-bus system is designed to proof the effectiveness of the presented energy trading method.

Keywords: Multi-Microgrid, Distribution Network, Stackelberg Game, Economic Optimization.

P1105

Nash Bargaining Based Active and Reactive Energy Trading Method for Microgrids in Distribution Network

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In this paper, the problem of microgrid group participating in active and reactive power trading on the distribution side is studied.

A Nash bargaining model based on cooperative game theory is proposed for the transaction between microgrid operators (MGO) and distribution network operator (DNO). Taking the optimal operating cost of direct transaction between MGO and DNO as the disagreement point of Nash bargaining. The solution of Nash equilibrium is obtained. Finally, a case study is given to verify the effectiveness of the proposed method in solving the economic dispatching problem of active power and reactive power.

Keywords: Microgrid, Cooperative Game, Nash Bargaining Solution, Reactive Power Compensation.

P1164

Vulnerability Analysis of Power System with Wind Farm Integrated Considering High-Speed Rail Loads

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With the increase of the high-speed rail loads scale and the integration of the large-scale wind power, the vulnerability of lines on the wind farm side is increasing. Thus, a vulnerability analysis method of the integrated grid-connected system of cluster high-speed rail loads and wind farm based on the branch potential energy function is proposed in this paper. Firstly, a PSCAD model is established based on the actual parameters of the traction power supply system and wind turbine. Secondly, a vulnerability analysis method based on the branch potential energy function is proposed. Finally, the simulations on a regional power grid in China show that compared with other methods, the proposed method considers the influence of the EMUs scale and the distance from the traction substation to the wind farm on the wind farm more comprehensively and accurately, and has practical application value.

Keywords: Vulnerability, Branch Potential Energy Function, High-Speed Rail Loads, Wind Farm, Electric Power System.

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P1187

Design And Analysis of Flexible Haptical System Based on Varistor Sensor Array

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This paper designs a small flexible haptical sensor array, and designs a test system based on the sensor array. The sensor array is made of pressure-sensitive materials, an insulating shell, and 16 strip conductors. Then a measurement circuit is built, and the resistance of the points on the array and the voltage output change with pressure are measured through the amplifier array and the data acquisition card; the array is gated and scanned by the data selector to obtain the realtime resistance change situation, real-time display in the form of three-dimensional graph with carrying out data processing. Finally, through single-point, multi-point and sliding experiments on the array, the output measurement results are obtained, which verifies the effectiveness of the flexible array and the haptical test system.

Keywords: Flexible Array, Haptics, Varistor Sensor, Haptical System.

P1235

Primary Frequency Regulation Technology of Power Grid and Frequency Regulation Potential Analysis of Hydrogen Fuel Cell

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Frequency stability is an important guarantee to maintain the safe operation of power system, and the high proportion of new energy integration puts forward higher requirements for the frequency regulation(FR) of power grid.

In this paper, based on the technical requirements and conventional methods of primary frequency regulation(PFR), the dynamic response characteristics of hydrogen fuel cell stack and power generation system considering the delay process of regulating valve are studied, and the frequency response characteristics of fuel cell power generation system are further simulated and analyzed. The results show that the fuel cell power generation system with seconds response delay can meet the demand of PFR and has the ability to participate in FR. The large capacity fuel cell power generation system, which is composed of battery group technology, has an important application prospect in the green and flexible FR of power grid by cooperating with the electrolytic hydrogen production system.

Keywords: Primary Frequency Regulation, Hydrogen Fuel Cell, Steady-State Characteristic, Frequency Response Characteristic.

P1272

Numerical Simulation of Internal Flow in Jumper Tube with Blind Tee

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Jumper tubes are widely used in the field of ocean engineering as a key component of oil and gas transportations. In order to improve the mixing conditions in the offshore pipelines, a blind tee is usually installed upstream of the measuring instrument to replace the elbow connections. The purpose of this research is to study the influence of the blind tees on the internal mixing conditions of the jumper tube. To this end, the three-dimensional flow fields inside the jumper tubes are solved with the Computational Fluid Dynamics (CFD) method, and the internal flow characteristics of the jumper tubes with blind tees installed at different positions are analyzed. The absolute axial vorticity is used to characterize the mixing conditions of the fluid in the jumper, and the vorticities at fifty-nine sections inside the jumper tube are extracted and compared under different configurations. The results show that compared to the traditional jumpers, the cross-sectional vorticity at the position where a blind tee is installed increases by range between 22% and 136%, and the corresponding dissipation speed decreases as well. It also reveals that the effect of installing blind tees at all elbow positions is not as good as that of using a single blind tee to increase the vorticity at some specific positions, especially for the outlet of the jumper tube.

Keywords: Jumper Tube, Blind Tee, Laminar Flow, Numerical Simulation, Flow Mixing.

P1273

Study on Working Medium Selection of High and Low Temperature Coupled ORC Scheme for Waste Heat Recovery of Dual-Fuel Ship Engine

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This paper made a comprehensive allocation of waste heat from W7X82DF model low-speed two-stroke marine Dual-Fuel engine regarded to its exhaust gas and jacket water waste heat and energy grade, and developed a combined organic Rankine cycle (ORC) system which can effectively utilize the cold energy of liquefied nature gas (LNG) and the waste heat of dual-fuel marine engine. Apart from that, we take the actual situation of heat transfer temperature difference into full consideration, and performance of twelve low-carbon green refrigerants with the situation that the value of ozone dissipation potential equal to 0 and global warming potential is less than 150. Through the closed circuit of the exhaust gas conversion device, the waste heat of the exhaust gas is driven to high-temperature cycle. Due to the advantages of large and stable flow of jacket water, and constant inlet and outlet temperature, it can be used as the heat source of lowtemperature cycle to recover the waste heat of jacket water. The process simulation software Aspen Plus was used to build the cycle, and the P-R equation physical property method was selected. According to the simulation curve, the following conclusions are drawn: R600a is more suitable as working medium of High-temperature cycle, thermal efficiency and net output power are 10.43% and 399.061 kW; The R600 is more suitable as the working medium of Low-temperature cycle, with the thermal efficiency and net power output of 12.88% and 340.13 kW respectively. Through the research in this paper, it provides a reference for the waste heat recovery of marine engine and improves fuel utilization and economy.

Keywords: Organic Rankine Cycle, Dual-Fuel Main Engine, Waste Heat Recovery, Aspen Plus, Low Carbon Working Medium, High And Low Temperature Coupling.

P1283

Integrated Optimization for Energy-saving Operation in Co-phase TPSS

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With the increasing scarcity of energy, more and more researchers have begun focus on the field of energysaving in railway system. A novel topology of traction substation integrated power flow controller (PFC) and hybrid energy storage system (HESS) based on co-phase power supply technology was studied in this paper to increase the utilization rate of regeneration braking energy (RBE) generated by train. And a bi-level optimization model considering the coordination effect of train trajectory optimization and HESS energy scheduling scheme was developed. Several cases studies have been proposed based on certain actual line to verify the effectiveness of this model. The obtained results show that this model effectively improves the utilization rate of RBE and reduces the electricity cost of traction power supply system (TPSS) by 28.02%.

Keywords: PFC, Co-Phase Power Supply Technology, Train Trajectory Optimization, Energy Scheduling.

P1313

Analysis of Air Gap Correction Method for 27.5kv Traction Power Supply System of Highland Electrified Railway

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This paper compared air gap and tolerance voltages correction methods on high altitude area, and based on them we analyze correction method considering the special environmental conditions of Sichuan-Tibet railway. With test results of short air gap in different areas of China, we verified the adaptability of insulation gap correction method at an altitude of 4000 to 4500m. As a result, we formulated a correction method and value of air external insulation under 50Hz overvoltage and lightning impulse overvoltage of 27.5kV traction power supply system at an altitude of 4000m to 4500m.

Keywords: Highland Electrified Railway, Air Insulation Gap, Altitude Correction.

P1332

Robust Game Optimization Scheduling Method for User-side Distributed Energy Storage

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Aiming at the economic scheduling problem of the system under multi-agent energy trading mechanism in open electricity market, this paper proposes a robust game optimization scheduling method for user-side distributed energy storage based on cooperative game theory. The purpose of this method is to coordinate the energy interaction between distribution network and users, and to find the equilibrium point of the game model to formulate the optimal user-side energy storage scheduling strategy, so as to improve the new energy consumption level and economic benefits of the system. Secondly, in order to reduce the influence of source and load uncertainty on the system economy in the actual dispatching operation process, robust optimization theory is used to deal with the uncertain factors. Finally, an example is given to verify the effectiveness of the proposed optimal scheduling method to improve the photovoltaic energy consumption level and reduce the operation cost of market entity.

Keywords: Source and Load Uncertainty, User-Side Energy Storage, Robust Optimization, Cooperative Game.

P1357

Review on the Risk and Treatment of Electric Vehicle Charging Pile Charging Leakage

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As the power supply source for electric vehicles, charging piles have caused frequent safety accidents due to electric leakage in recent years, which has attracted high attention from the society. The electricity risks of charging piles will directly affect the sales and promotion of electric vehicles. According to the different types of leakage current, the application of residual current protection is introduced in detail, and the corresponding leakage protection is analyzed on the basis of the four different charging modes of charging pile. At the same time, the influence and harm of other electric vehicle charging leakage and DC leakage is studied. Finally, through the comparison and summary of existing technologies, the future development trend of intelligentized charging piles is proposed. It not only helps to enhance the understanding of electric vehicle charging safety issues, but also provides a new direction for the application and innovation research in this field.

Keywords: Electric Vehicles, Charging Piles, Charging Leakage, Electrical Safety.

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P1367

Research on Prediction of Photovoltaic Power Generation Probability Interval Based on Gaussian Mixture Model

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This paper proposes a method of photovoltaic power generation probability interval prediction based on Gaussian mixture model. The method first uses the K-means algorithm to divide historical photovoltaic power generation data by weather, uses a Gaussian mixture model to fit the divided prediction errors, and uses an expectation maximization algorithm to estimate model parameters. Predict the probability interval of photovoltaic power generation by calculating the confidence interval under the specified confidence level. The simulation results show that the performance evaluation indexes of the proposed method are better than the typical single distribution model when forecasting the photovoltaic power interval, which proves the accuracy and applicability of the proposed method.

Keywords: Photovoltaic Power Generation, Gaussian Mixture Model, Error Distribution, Weather Division.

P1393

Multi-core Identification of Mixed Power Disturbances

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In order to solve the problem of edge overlap between typical classification features of mixed power disturbances, a new method that uses multiple feature extraction methods to identify the types of disturbances is proposed in this paper. Firstly, the different characteristic curves is analyzed to illustrate the effectiveness of multiple feature extraction methods in the identification of mixed disturbances. Secondly, in order to consider the correlation between high-dimensional features and target categories and the standardization of measurement scales, the improved maximum correlation minimum redundancycriterion is used to select the key feature subsets that are effective for identification, and then the multi-core SVM(Support Vector Machine) that takes into account the radius information is used to identify the mixed power disturbances. Finally, the simulation results show that the identification algorithm proposed in this paper can effectively identify various disturbances under different noise intensities, which demonstrates the effectiveness and feasibility of the proposed algorithm. This method overcomes the influence of mixed power disturbance feature space ambiguity on the identification accuracy, which is less affected by noise and has good stability.

Keywords: Disturbance Identification, Feature Selection, Multi-core SVM, Radius Information.

P1174

Optimal Power Distribution of Fuel Cell Electric Trucks via Convex Programming

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This article develops optimal power distribution strategies for the fuel cell electric truck. Based on the power system models of the non-plugin fuel cell electric trucks, a convex programming problem is formulated to optimize the power management between a fuel cell system and a battery pack. At the same time, the power following and thermostat control strategy for the fuel cell electric truck, is implemented. The hydrogen consumptions are systematically investigated under the China heavy-duty commercial vehicle test cycle and the Chinaworld transient vehicle cycle. Finally, based on the developed control strategy, we examine the power distribution of the fuel cell electric truck under different drive cycles.

Keywords: Power Distribution, Fuel Cell Electric Truck, Convex Optimization, Rule-based Strategy.

P1009

Optimal Scheduling of HESS for FTPSS Considering HESS Degradation Cost

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To solve the problem of power quality (PQ) and neutral zone (NZ), a flexible traction power supply system (FTPSS) is proposed. This paper studies the energy management of FTPSS consisted of the hybrid energy storage system (HESS) and photovoltaic (PV). The model of battery degradation cost related to battery cycle depth is established, which is linearized by the piecewise linearization method. Based on traction load simulation data and PV prediction data, mixed-integer linear programming (MILP) model is established with the goal of minimizing the comprehensive cost. The comprehensive cost includes HESS degradation cost, PV operation and maintenance (O&M) cost, and electricity. The simulation results verify the significant economic-saving potentials of the proposed model in the FTPSS.

Keywords: Flexible Traction Power Supply System, Energy Management, HESS Degradation Cost.

P1262

Lithium-ion Battery SOC Estimation Based on an Improved Adaptive Extended Kalman Filter

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Battery is an important driving force of electric vehicles. Reasonable utilization of battery energy is a key link of battery management system. The battery management system can ensure the safety and efficiency of the battery by accurately estimating the SOC of the battery. In this paper, based on the establishment of battery equivalent model and parameter identification, a new battery SOC estimation method is proposed. This method is improved on the extended Kalman filter, and an adaptive filtering algorithm is used to solve the noise problem. Firstly, the theoretical analysis of the algorithm is completed. Finally, the simulation is carried out in MATLAB environment to verify the feasibility of the algorithm.

Keywords: Lithium-Ion Battery, Equivalent Circuit Model, SOC Estimation, Parameter Identification, Extended Kalman Filter.

P1378

Multi-Region Distributed State Estimation Method for Natural Gas System

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A multi-region distributed state estimation method for natural gas system is proposed. A measurement model of the natural gas system is established, a node search partition method based on the balance area is proposed, and the node pressure in the gas network is used as the state estimation estimate to establish a multi-regional distributed natural gas system based on the weighted least squares algorithm. State estimation model, and Newton Raphson iterative method is used to solve the state estimation model. The correctness and effectiveness of the proposed method are verified through simulation examples in a 12-node system, and the estimation error and estimation duration are compared with the traditional centralized state.

The estimation methods are compared. The simulation results show that the distributed state estimation method can effectively reduce the estimation error and estimation time, and is suitable for the state estimation of the network with more complex structure and larger measurement data volume.

Keywords: Natural gas system, Multi-zone system, Distributed state estimation, Weighted least squares.

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P1039

Automation Disassembly Sequence Generation Based on Visual Recognition and Rules in Remanufacturing

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Disassembly is a vital process for remanufacturing. Generating the feasible disassembly sequences for end-of-life products is an evitable step before executing the disassembly process. For most existing methods to generate the feasible disassembly sequences, CAD model of products should be provided. However, when the CAD model could not be provided, additional methods should be utilized to generate the feasible disassembly sequences. Especially for the situation that a part of this product is missing, the feasible disassembly sequence should be dynamically generated. In this paper, the disassembly rules are manually summarized. And, the feasible disassembly sequences are generated based on visual perception and rules. The method of deep learning is utilized to recognize the parts of end-of-life products. Finally, case studies under different scenarios based on double-axis diaphragm coupling are carried out to verify the proposed method.

Keywords: End-of-Life Products, Visual Recognition, Disassembly Sequence Generation, Disassembly Rules.

P1091

A Precise Measure Method for the Unbalancing Vector of Spindle in Ultra-precision Diamond Turning

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For the ultra-precision single point diamond turning, the spidle system is a core component and plays a decisive role in precise machining. The unbalancing state in spinle can degrade the quality of machining surface. Therefore, the spindle system must be exceptionally well balanced before processing. A precise the spindle unbalancing measurement method, adopting the real-time data in CNC System of SPDT and combining with disturbance observer (DOB), is proposed. According to the experiment result, the accuracy of this method is up to G0.00648. Since this method does not require addition sensors to install, it is easily popularized and applied in the field of ultra-precision machine tools.

Keywords: Ultra-Precision Diamond Turning, Spindle Dynamic Balancing, Disturbance Observer (DOB), CNC controller.

P1094

Job Shop Scheduling in Discrete Manufacturing Based on Improved Hybrid Lion Swarm Optimization

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Job shop scheduling problem (JSSP) is a NP-hard problem, which is widely used in manufacturing industry. In this paper, we proposed an improved hybrid Lion Swarm Optimization (IHLSO) algorithm for the JSSP based on the actual production requirements. The proposed IHLSO included two improved algorithms, which were respectively hybrid Lion Swarm Optimization (HLSO) algorithm and HLSO with Solis–Wets (SW) local search algorithm (SW-HLSO). IHLSO improved the global searching ability of basic Lion Swarm Optimization (LSO) algorithm by combing Particle Swarm Optimization (PSO) algorithm and improved the local searching ability by applying SW algorithm. Tests on the benchmark instances of the JSSP showed excellent performance of the improved LSO.

In the actual production scene of machine tool manufacturing enterprises, the algorithm proposed in this paper is more suitable for the demand of factory scheduling than other methods. In addition, in order to facilitate the application of the algorithm in actual production and help the employees to arrange production more conveniently, we had designed a Graph User Interface (GUI) to realize intelligent production scheduling in digital workshop.

Keywords: Job Shop Scheduling Problem, Lion Swarm Optimization, Particle Swarm Optimization, Optimization Methods, Intelligent Manufacturing.

P1098

Intelligent Appearance Quality Detection of Air Conditioner External Unit and Dataset Construction

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With the development of the Industrial Internet of Things (IIoT) and the upgrading of the manufacturing industry, intelligent solutions for factories are imminent. Nowadays, most factories have backward testing methods and low efficiency, which has gradually become the shackles of enterprise development. Aiming at the problem of the appearance quality of the air conditioner external unit, this paper proposes an intelligent detection solution for the appearance quality of the air conditioner external unit based on the YOLO object detector, and constructs an image dataset containing with 25897 images and object labels. In the actual test, the object labelled in the quality inspection task of the air conditioner external unit reached a recall rate of more than 99% and a mAP of more than 95%.

Keywords: Appearance Quality Detection, Object Detection, YOLO, Air Conditioner External Unit, Dataset Construction.

P1154

Fault Diagnosis of Series Batteries based on GWO-SVM

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Nowadays, the fault diagnosis of battery internal resistance and contact resistance in EV series batteries is based on experience and has no clear diagnostic criteria. To solve this problem, the grey wolf swarm optimization support vector machine (GWO-SVM) is proposed. Acquiring the data in the published papers about the changes of resistance under the internal resistance and contact resistance fault. The sample data of normal condition and battery internal resistance fault, contact resistance fault, battery internal resistance and contact resistance mixed fault are simulated in Simscape and imported into GWO-SVM and other artificial intelligence diagnosis models. The results show that the proposed GWO-SVM has higher diagnostic accuracy than other diagnostic models in fault diagnosis of tandem battery packs, maintaining a higher accuracy rate in the case of mixed faults. This method is capable of distinguishing various types of faults effectively.

Keywords: Series Batteries, Battery Internal Resistance, Contact Resistance, Mixed Fault, GWO, SVM.

P1219

A Power Grid Fault Center Identification Method Based on Feature Vector Centrality

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A power grid fault diagnosis method is proposed based on the graph signal modeling according to the fault recording start information and the network node eigenvector centrality algorithm. Firstly, the fault start information network diagram is constructed from the fault record start information of relay protection and fault information master station. Secondly, the graph smoothness analysis method is used to determine whether the grid fails and identify the fault type. Finally, the fault components are identified based on the feature vector centrality algorithm of network nodes and visualized. The simulation verifies the effectiveness of the proposed algorithm. As a part of the intelligent fault analysis of wave recording, this method helps to quickly grasp the fault situation of power grid, and focus on collecting wave recording data for fault analysis and verification, so as to improve the efficiency of wave recording analysis.

Keywords: Start Information, Figure Smoothness Analysis, Feature Vector Centrality, Fault Recording Intelligent Diagnosis.

P1379

Technology Network Construction and Analysis Method for Technology Trends Discovery

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Patents and technologies are important references in the product design process, it is important to know the future trend of developing technology for the improving of product innovation design ability. Therefore, to analyze the law of the technology development and provide a reliable patent analysis process for new product development, a technology network model based on complete graphs is constructed to describe the future trend of technologies. Based on the technology network model, a patent analysis process that analyzes the trends of technology is provided. To illustrate the feasibility and validity of the proposed methodology, a case study with 9489 patents on electric vehicles between June 2011 and June 2016 from USPTO (United States Patent and Trademark Office) is performed.

Keywords: Product Design, Technology Acquisition, Patent Analysis, Technology Network Construction and Analysis.

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P1408

Multi-Agent Reinforcement Learning-based Distributed Economic Dispatch Considering Network Attacks and Uncertain Costs

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With the development of large-scale power grids, distributed economic dispatch has received considerable attention. However, existing distributed economic dispatch algorithm signore potential network attacks, which may have a greaterimpact on the security of the power grid. In addition, due to the access of renewable power generation equipment andexternal interference, there are usually uncertain terms in the cost function. A distributed economic dispatch collaborative deeprein forcement learning algorithm considering the safety objective function is proposed. All agents in the algorithm make joint decisions by observing the environment and coordinating with local neighbors. The state action value function is approximated by a neural network. Aiming at the problem caused by the uncertain term of the objective function, the idea of lenient reinforcement learning is adopted, and the reward is also fitted with a neural network. Several case studies have been conducted to prove the advantages of this algorithm.

Keywords: Multi-Agent Reinforcement Learning, Securityeconomic Dispatch, Communication Network Attack, Neural Network.

P1411

The Circuit Fault Diagnosis Method Based on Spectrum Analyses and ELM

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To overcome the difficulty of the circuit fault diagnosis in analog circuits, which is hard to analysis and judgment by traditional method, a novel method based on frequency domain analysis and ELM neural network is proposed. Since the circuit frequency response curve can reflect the operating state and characteristics of the circuit, when a fault occurs, the frequency response characteristic curve will also change. By analyzing the changes in the transfer spectrum characteristics to determine whether it is in a fault state, this method has clear physical meaning and good robustness. The training process can be simplified by using ELM neural network. Through simulation and experiment, the results show that the method is sensitive and feasible for the circuit fault detection.

Keywords: Circuitsfault Diagnosis, Spectrum Analyses, ELM.

P1158

A Real-time Reconfigurable Edge computing System in Industrial Internet of Things Based on FPGA

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In the environment of industrial Internet of things, due to the complexity and variability environment, edge computing related technologies are being widely applied. However, the edge node is constrained by cost, volume, power consumption and other conditions, so the ability of edge computing can not be fully played. In order to make edge computing give full play to its characteristics of flexible management, collaborative execution and heterogeneous environment. This paper proposes a realtime reconfigurable edge computing system based on FPGA. The system can be built in real-time according to the requirement, by the characteristics of FPGA, including reconfigurable, partial reconfigurable and precise clock control. The system is divided into three parts from macro to micro structure, including: cloud-based configuration information management module, high-performance embedded module based on FPGA and combinable function module based on multiprocessor core. Result shows that the system can meet the remotely configuration of cloud according to the environment and requirement of the edge end, so as to quickly build a edge computing system that matches the environment and requirements.

Keywords: Edge computing, FPGA, Industrial Internet of Thing, Reconfigurable system.

P1382

Design and Expansion Development of Embedded System Software for a New Intelligent Hematology Analyzer

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Hematology analyzer is widely used in clinical tests in the hospital. In order to meet the needs of clinical diagnosis, various new detection function has been added to hematology analyzer to achieve joint detection of multiple parameters.

Based on rapid software design and extended development methods, the design and implementation of a new intelligent hematology analyzer software are explored in this paper, and the overall design of the control node and management node are introduced, also, the software implementation of the CAN communication module and fault detection mechanism are given. The new intelligent hematology analyzer is based on the functional module of existing three-diff standard hematology analyzer, using a distributed system architecture which adopt CAN bus for communication. The CRP detection is attached to the original routine blood test, extending a new detection module only needs to increase the control node and modify the upper level. The test result shows that the new intelligent hematology analyzer based on the distributed architecture has good reliability and scalability, and can realize the rapid expansion of external modules.

Keywords: Embedded Technology, Distributed Control System, Multifunctional Hematology Analyzer, CAN Bus.

P1418

D-Optimal Design for Information Driven Identification of Static Nonlinear Elements

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Identification of static nonlinear elements (i.e., non-linear elements whose outputs depend only on the present value of inputs) is crucial for the success of system identification tasks. Identification of static nonlinear elements though can pose several challenges. Two of the main challenges are: (1) mathematical models describing the elements being unknown and thus requiring black-box identification; and (2) collection of sufficiently informative measurements. With the aim of addressing the two challenges, we propose in this paper a method of predetermining informative measurement points offline (i.e., prior to conducting experiments or seeing any measured data), and using those measurements for online model calibration. Since we deal with an unknown model structure scenario, a high order polynomial model is assumed. Over fit and under fit avoidance are achieved via checking model convergence via an iterative means.

Model dependent information maximization is done via a D-optimal design of experiments strategy. Due to experiments being designed offline and being designed prior to conducting measurements, this method eases off the computation burden at the point of conducting measurements. The need for in-the-loop information maximization while conducting measurements is avoided. We conclude by comparing the proposed D-optimal design method with a method of in-the-loop information maximization and point out the pros and cons. The method is demonstrated for the single-input-single-output (SISO) static nonlinear element case. The method can be extended to MISO systems as well.

Keywords: Black Box, Design of Experiments, DoE, D-optimal, Estimation, Nonlinear Systems, Optimal Design, Optimization, Over-Fitting, System Identification.

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P1114

DRAT : A Penetration Testing Framework for Drones

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As the usage of drones increases, attack vectors to exploit the vulnerabilities increases as well; particularly in commercial off the-shelf Wi-Fi based drones. Hence, drones must be carefully evaluated and selected before deployment in the field. Penetration testing is a way to assess the vulnerabilities of drones, but it may require multiple commands, files or scripts and tools to generate and store the results. Many of these existing techniques and tools are dependent on human control and intervention. In this paper, we propose a Drone Pen-testing tool, which has integrated resources to conduct, organize the penetration tests and store the results. The tool has 3 main operation modes–Admin mode, User Mode and Machine learning mode. In Machine learning mode, the tool passively collects the network traffic from Wi-Fi drone access points for 60 seconds. The collected network traffic (in a pcap file) is used to analyze the IEEE 802.11 b/g/n protocol stack to identify a specific target among the surrounding Wi-Fi drones. This feature helps the user to launch a targeted attack quickly for a particular type of drone when the surrounding has many active drones.

The paper explains the features of the scalable and easy to use, GUI (Graphical User Interface) based framework including details of its machine learning mode.

Keywords: Drone Security, UAV, penetration testing, vulnerability, framework, Wi-Fi, 802.11 packets, Machine Learning in Drone Security.

P1314

Fair Rewarding Mechanism for Sharding-based Blockchain Networks with Low-powered Devices in the Internet of Things

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Contributing to mining algorithms using lowpowered devices is one of the principal concerns in the growth of the Internet of Things (IoT) paradigm. To address this limitation, we introduce a new concept of allocating mining devices based on their computation power in sharding-based blockchain systems for the IoT. This study proposes two scenarios based on different ways of partitioning the transactions into the disjoint shards: Scenario 1 (Number of processors are equally distributed among shards); Scenario 2 (Number of processors are distributed among shards using computation power-based criterion). We also adopt an adversary model to obtain the fraction of participating processors that must be compromised by the adversaries to compromise our proposed method of sharding based blockchain networks. Our results demonstrate that the total computation cost of the entire system increases when the computing cost for verifying signatures and the number of shards increases. We observe that the total reward of each processor increases when the number of less powerful processors increases. The total number of mined processors of each shard decreases with a high number of less powerful processors. Thus, the total reward of the entire network is distributed among a few processors. We demonstrate that our new method of allocating mining devices based on their computation power (Scenario 2) provides fair reward distribution. Additionally, when the total number of processors in a network is higher than 500, each processor's total reward increment shows an insignificant change. However, when the total number of processors is lower than 500, each processor's total reward shows an upward linear trend and contradicts the assumption of Scenario 1. Thus, our results show that the proposed model (Scenario 2) is more suitable for allocating mining devices based on their computation power in shardingbased blockchain systems for IoT, especially devices with different computational capabilities or processors with selfish behavior.

This concept motivates powerful processors to verify and validate new transactions to be added to the blockchain.

Keywords: Blockchain, Sharding-Based Blockchain, Processor Allocation, Computation, Internet of Things, IoT.

P1315

Latency Estimation of Blockchain-Based Distributed Access Control for Cyber Infrastructure in the IoT Environment

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We adopt a permissioned blockchain framework to enable the Internet of Things (IoT) device access control, primarily to protect cyber infrastructure (cloud, fog, web servers, application servers, routers, switches, gateways, remote sensors, computers, controllers, actuators, radio transceivers, storage, including computing grid and data grid) of the IoT networks. The connected smart devices or critical cyber infrastructures continuously contribute to collect and transfer a vast amount of data using the internet. Unauthorized access and unauthenticated control of these devices would generate severe catastrophes. Despite the risk of having single-point-of-failure that occurs due to the centralized nature, Certificate Authorities (CAs) contribute to the security when devices hold CA-signed certificates. This study develops a comprehensive latency model on blockchain based distributed critical infrastructure access control in the IoT networks. Decentralized Security Access Administrators (SAAs) are used instead of centralized CA to provide blockchain-based distributed access control to protect critical infrastructure. For our estimation, we consider (i) communication latency, (ii) digest computation latency, (iii) message authentication codes (MACs) computation latency, (iv) latency for device access query via SAA, (v) latency for authorization and device access, and (vi) latency for adding a transaction to the blockchain. Additionally, we compare the estimated time consumption of our model with a prior study. Our results indicate that the existing model underestimates latency by 75.5%. We estimate accurate time to access a target object using blockchain securely. This model is practical (i) to observe the scalability performance of a network and (ii) to detect malicious traffic by observing time. Adding a new block to blockchain incurs more delays than it claims, especially in the blockchain-based IoT environment. Understanding the accurate delay, theoretically, is essential to such systems. Our study moves a step forward towards this direction.

Keywords: Blockchain, Distributed Ledger Technology, Latency, Cyber Infrastructure, Certificate Authorities (CAs), IoT

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P1030

Hubble: An End to End Approach for Anomaly Detection in Network Traffic

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Fast and accurate detection of abnormal network traffic is of great significance to improve the stability and security of the network. In recent years, the research on anomaly detection of network traffic based on deep neural network has made substantial progress. However, existing network traffic anomaly detection methods mainly focus on learning new feature representations to anomaly detection methods, lead to data-inefficient learning and suboptimal anomaly scoring. Furthermore, they are typically designed as unsupervised learning methods due to the lack of large-scale labeled anomaly data. As a result, they are difficult to leverage the prior knowledge when such information is available as in many real-world anomaly detection applications.

To tackle the aforementioned fundamental challenges, in this paper we introduce Hubble, a end to end anomaly detection framework for efficiently, accurately, and quickly detecting the abnormal information embedded in network traffic data. There are three key components combined to successfully achieve the above objectives, the feature extractor for fast traffic encoding learning, the anomaly scorer for accurate detection anomaly data, and the multi- classifier for diverse abnormal types. The extensive results show that Hubble can be trained substantially improving abnormal detection accuracy by 25.1% and reducing detection time up to 44.6% on average compared to state-of-the-art methods in network traffic.

Keywords: Anomaly Detection, End to End, Multi-classification, LSTM-encoding, Network Traffic.

P1045

Design of Real-time Video Transmission System Based On 5G Network

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In order to make up for the deficiency of traditional industrial terminals such as high video transmission delay and low speed, this paper researches and designs a video transmission system based on 5G technology. 5G is the most disruptive technology in the industrial Internet field. It is characterized by high speed, low latency, large capacity, mobility, security, etc. This system takes advantage of Rockchip RK3399 as the core processor for video data processing and makes use of Huawei MH5000 5G industrial module to connect to 5G wireless network. The 5G terminal device transmits the video data to the server through the 5G network, and the video data is forwarded to the client through the server for display. In this paper, a video data transmission protocol is designed for the real-time transmission of UAV video. This protocol can reduce the delay of video capture and transmission to client display. This system compares and analyzes the video transmission effects of several wireless transmission schemes. A large number of experiments have verified that the 5G video transmission delay is 49ms and 23 frames per second, which meets the needs of industrial applications.

Keywords: Video Transmission, 5G, Image Acquisition, ARM.

P1079

Research of Webpage Complexity Influence on Search Behavior Based on Eye Tracking Experiment

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With the development of the Internet, users use electronic devices to browse information continuously for a long time every day. Excessive information brings a lot of cognitive load to users. Many studies have shown that the complexity of the webpage design will affect the search efficiency. For e-commerce webpages, the search efficiency is directly related to the purchase rate. Therefore, through eye tracking experiments, this paper studies the influence of density factors of e-commerce webpage complexity on user search behavior performance and subjective perception, establishes the relationship between webpage visual design and user search usability, and comprehensively constructs evaluation indexes from behavior data and perceptual data. The research results of this paper provide a reference for designers how to arrange information density when designing webpages.

Keywords: e-Commerce Website, User Experience, Webpage Complexity, Search Efficiency, Eye Tracking.

P1242

Design of UAV Video And Control Signal Real-Time Transmission System Based on 5G Network

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In order to ensure the long-distance, low-delay and high-rate reliable transmission of civil UAV video signals and control signals, and solve practical application problems, this paper studies and designs a real-time transmission system for UAV video signals and control signals based on 5G network. The onboard computer uses Nvidia Jetson Nano, and the 5G module uses Huawei MH5000 module. In addition, the H.265 encoding method is improved for the characteristics of UAV video, and the MAVLink protocol is used as the control signal transmission protocol. The system has the characteristics of wide application range, high reliability and low delay. At the same time, a physical platform was set up to conduct experiments. After a large number of repeated experiments, the end-to-end transmission delay of the video signal was measured to be 1.2s, the transmission rate was 97Mb/s, and the control signal response delay was 30ms. This performance fully meets the application requirements of civilian UAVs.

Keywords: Signal transmission, 5G, Video coding, MAVLink.

P1085

Research on Information Interaction Scheme of Charging Pile based on IEC61850

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The construction of high-reliable and highefficiency charging pile is the foundation and premise for the healthy and rapid development of the electric vehicle industry, and it is very important and necessary to study the corresponding information interaction scheme in order to realize the plug-and-play function of the charging pile. Based on the IEC61850 standard, this paper studies the charging pile information description model and puts forward the communication technology to satisfy the requirement of the plug-and-play. Moreover, the charging pile status information, setting, control and measurement values are considered in the information interaction strategy. This research can provide effective technical means and solutions for the realization of plug-and-play function of charging pile.

Keywords: Charging Pile, Plug-and-Play, Information Description Model, Information Interaction Scheme.

P1392

A Charging Station Centric Cooperative Edge Computing Architecture for Computation of Electric Vehicles and Charging Facilities

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In recent years, with the rapid development of the new energy industry, electric vehicles and urban electric vehicle charging equipment have been rapidly developed. To improve charging efficiency and users' quality of experience, more computing resource is requested for charging optimization. Edge computing is an effective way to provide intelligent computing capabilities. Considering that the edge computing nodes will be more and more intensive, in this paper, we propose a charging station centric cooperative edge computing architecture for electric vehicles and charging facilities. We first give the overall design of this architecture, and then describe the navigation system, deep learning module and computing resource virtualization in detail. Finally, simulation experiments are conducted on the calculated load and average user waiting time at nearby base stations during charging to demonstrate the efficiency of the intelligent computing proposed in this paper.

Keywords: Electric Vehicle Charging, Edge Computing, Deep Learning, Resource Virtualization.

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P1007

Transient Analysis of the Suspension Electromagnet Winding Terminal Current

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Suspension electromagnet (SEM) is the energy conversion device of the low-speed maglev train. The system adjusts the winding current by the chopper to change the electromagnetic force to realize the contactless operation between the train and the track. The SEM winding is equivalent to a time-varying inductance, and the parasitic capacitance of the winding affects the transient performance of the chopper. This paper proposes an analytical method for calculating the inrush current of the winding. Firstly, the functional expression of the winding terminal voltage is derived by Fourier transform. Then, the SEM winding is equivalent to a black box impedance network composed of inductances, resistances, and capacitances. Finally, the transient response expression of the winding terminal inrush current is deduced according to the circuit superposition theorem. The analysis results show that the inrush current at the moment of chopper switching is the superposition result of the current components with different frequencies through the equivalent series resonant circuit. Finally, the results of the simulation and experiment show the correctness of the proposed method.

Keywords: Maglev Train, Suspension Electromagnet (SEM), Parasitic Capacitance, Inrush Current, Fourier Transform.

P1015

Robust Impedance Reshaping of Multiple Ongrid Inverters regarding Variable Grid Conditions

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To avoid the cost of extra high-precision sensing circuit, single injected current feedback control scheme has been developed to complete both current regulation and active damping control of LCL-type filter-based grid-connected inverter. However, traditional single current feedback control method is sensitive to the variation of grid impedance. This paper will address this problem by reshaping the inverter output impedance with an added low-cost two-switch auxiliary circuit in the filter capacitor branch. Because the auxiliary circuit requires very low power rating, it does not sacrifice the efficiency of the inverter. Compared with the traditional single injected current feedback control method, the inverter output impedance with the proposed method possesses sufficient passivity and robustness in the frequency range of interest. To verify the validity and feasibility of the proposed method, comparative experimental waveforms are given in the paper.

Keywords: Inverter, Impedance Reshaping, Passivity, Weak Grid.

P1020

Comparison of Different Neutral Point Balance Strategies Applied to Three-Level DFIG System

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When the rotor-side converter (RSC) in the doubly-fed wind power generation system adopts the three-level structure, the neutral point voltage (NPV) is difficult to balance. In this paper, two types of average neutral point current (NPC) models in the three-level converter (TLC) are summarized. Symmetric SVPWM and virtual SVPWM based on space vector are analyzed. CBPWM with zero-sequence voltage injection and changing duty ratio CBPWM (CDR-CBPWM) based on carrier wave are investigated. CDR-CBPWM is simplified for application. The effects of symmetric SVPWM and simplified CDR-CBPWM applied to RSC are compared through simulation.

Keywords: Doubly-Fed Induction Generator, Three-Level Converter, Neutral Point Voltage, Neutral Point Current.

P1034

Power Characteristic Analysis of PMSG Based on Voltage Source Control

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This paper presents a voltage source control of PMSG (permanent magnet synchronous generator) suitable for the weak grid. Based on providing the control strategies of the PMSG-side and grid-side converters respectively, the model of grid-side converters has been built. Considering the voltage loop and current loop, the small-signal active power transfer function of the grid-side converter has been obtained. Then this paper analyzes the influence of virtual inertia coefficient, virtual damping coefficient, and grid strength on power transmission. Finally, the correctness of the model and analysis is verified by Matlab/Simulink simulation.

Keywords: Voltage Source Control, PMSG, Weak Grid, Power Characteristic, Grid-Side Converters.

P1035

Fault Ride-Through Control Strategy of Doubly-Fed Wind Turbine Under Symmetrical Grid Faults

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For doubly-fed induction generators (DFIG), large induced electromotive force will be generated in the rotor circuit during grid failure. Without proper protection measures, the rotor circuit of the doubly-fed motor will generate a large inrush current and even damage the rotor-side converter (RSC). Aiming at this problem, this paper proposes a low-voltage ride-through (LVRT) control strategy for voltage source doubly-fed wind turbines based on transient compensation. First, the transient model of the stator flux linkage of the motor is analyzed, and the transient compensation is injected into the rotor side in a timely manner. Then, the phase angle of the compensation is optimized through vector analysis, which minimizes the rotor current impact at the moment of failure and enhances the stable operation of the doubly-fed wind generator under grid failure. Finally, this paper verifies the correctness of the proposed strategy through corresponding simulations.

Keywords: DFIG, Low-Voltage Ride-Through, Transient Compensation, Phase Angle Optimization.

P1037

Enhanced Efficiency of Wireless Power Transfer Using Slotting in the Metals

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Wireless power transfer (WPT) is greatly affected when the transmission channel is surrounded by non-ferromagnetic metallic objects. In order to minimize the influence of metals, a method of etching on the metal plate is proposed in this paper. The effects of various lengths, shapes, thicknesses of slots and thicknesses of metal plate are studied. The results show that effective slots should meet four key requirements, namely, reaching the edge of the metal plate, passing through the inner area of the coil projection, etching through the metal in the thickness direction, and the thickness of the metal plate is much smaller than the skin depth. The H-shaped branch structure is considered to be the best branch, and the composite slot shape formed by the H-shaped branch and the cross has the best system improvement. In addition, this kind of graphics is uncomplicated and could be easily realized by existing cutting methods. The conclusions of this paper provide references for the design and optimization of WPT system.

Keywords: Wireless Power Transfer, Non-Ferromagnetic Metal, Slot, Eddy Current Losses.

P1043

An Adaptive Robust Predictive Current Control Scheme With Online Parameter Identification Based on MRAS for High-Performance PMLSM Drives

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Predictive current control (PCC) has excellent transient performance, which is a research hotspot in permanent magnet linear synchronous motor (PMLSM) control system. However, model mismatch and parameter variation will result in the current static error and even the system instability.

Generally, the parameters will change as the motor runs. Therefore, to solve the problem of parameter dependence in PCC and achieve high performance control of the PMLSM control system, a model reference adaptive system (MRAS) which can identify the inductance and permanent magnet (PM) flux linkage simultaneously is proposed and applied. The simulation and experimental results verify the correctness and effectiveness of the researched scheme.

Keywords: PCC, PMLSM, Robustness, MRAS.

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P1046

Modeling and Matlab Simulation of the Inverter Based on Bond Graph

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The multi-mode operation of inverter brings great challenges to the modeling of wind power generation system. Regarding the discontinuities and hybrid characteristics of switching in the inverter, this paper uses nonlinear resistive elements to perform equivalents. Based on bond graph theory, the model of inverter is constructed and the unified modeling is realized. With the help of Matlab simulation platform, a simulation model is established under the proposed module construction method. The simulation results show the capability of bond graph theory to overcome the problem of discontinuous state in hybrid systems, and nonlinear resistive elements equivalent to switching devices is demonstrated to be effective. In addition, the module construction method is proved to be convenient and practical when establish the bond graph simulation model.

Keywords: Inverter Modeling, Bond Graph, Switching Equivalent, Module Construction Method.

P1054

Research on MPPT of Photovoltaic Power Generation based on Backstepping Method

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In photovoltaic power generation systems, traditional algorithms have the disadvantage of poor maximum power point tracking (MPPT) stability and cannot accurately find the maximum power point (MPP). In order to solve these problems, this paper proposes a backstepping control method based on Lyapunov function, which can not only improve the stability of the system, but also accurately find the MPP. By comparing the results of the two algorithms through experiments, it is verified that when the external environment changes, the output waveform of the Backstepping method is more stable, the fluctuation is smaller, and the robustness is stronger.

Keywords: Photovoltaic Power Generation, MPPT, Backstepping Control.

P1070

Experimental and Variance Analysis on Flame Propagation Behaviors in Coal Dust Explosions

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Dust explosions are phenomena in which a flame propagates through a dust cloud in air with increasingly subdivided combustible solids. These events are common risks in the coal, metallurgy, chemicals, wood, food processing, explosives and other industries. In order to study the propagation characteristics of coal dust explosion flame, box graph and two-factor variance analysis were used to explore the influence of coal dust metamorphism degree and coal dust particle size on the propagation characteristics of coal dust explosion flame in this paper. Specifically, a certain coal sample was selected and the coal dust explosive identification test was carried out through the modified MCB-III intelligent coal dust explosive identification instrument. By observing box graph, the different influence rules of metamorphism and particle size on the length of coal dust explosion flame were analyzed qualitatively. The results show that, the main factor affecting the length of coal dust explosion flame is the size of coal dust.

Keywords: Coal Dust Explosion, Flame Length, Analysis of Variance, Experimental.

P1071

Optimization of Complex Mine Ventilation System Based on AHP-WRSR

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Within the mining industry, a safe mine ventilation system is an essential component of all underground mines. The mine ventilation system is responsible for supplying fresh air to the underground, meeting the breathing requirements of worker, diluting the gas attached to the coal, discharging toxic and harmful gases, reducing the air temperature of working environment. It is very necessary to optimize a complete and reasonable scheme of mine ventilation system to ensure a safe and acceptable working environment. In this paper, the Analytic Hierarchy Process-Weight Rank Sum Ratio (AHP-WRSR) evaluation model is constructed to optimize the reconstruction scheme of mine ventilation system and a mining engineering example is used to verify the effect of this method. Specifically, based on the ventilation system transformation in Sihe coal mine as an example, a total of 20 modification schemes of 6 categories were established and the results obtained by AHP-WRSR are consistent with the field application. It was proved to be reliable, utile and prospect through comparison.

Keywords: Ventilation System, AHP, Scheme Optimization, WRSR

P1077

Dosimetry Simulation Research on Electromagnetic Exposure of Wireless Charging Electric Vehicle to Human Central Nervous System

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To evaluate the safety of electromagnetic exposure of a magnetic coupling resonance wireless charging system in electric vehicles on the human central nervous system, COMSOL Multiphysics software is used to establish electric vehicle models with different materials and thicknesses, a magnetic coupling resonance wireless charging system model, and a human body model.

The electromagnetic exposure of the electromagnetic field generated by the wireless charging system to the central nervous system of the human body in the electric vehicle with carbon fiber-reinforced plastics (CFRP) car body, aluminum alloy car body, and low carbon steel car body with different thickness shielding is simulated and analyzed. The simulation results show that CFRP, aluminum alloy, and low carbon steel vehicles can effectively shield electromagnetic fields. The shielding effect of CFRP and aluminum alloy car body improves with the increase of thickness, and the shielding effect of low carbon steel car body worsens with the increase of thickness. Under the worst shielding condition, the maximum magnetic induction strength and electric field strength of human head are respectively 0.9 μT and 0.18 V/m, the electromagnetic exposure level to the human head is less than the public exposure limit of 27 μT and 2.97 V/m set by the International Commission on Non-Ionizing Radiation Protection. Results show that the magnetic coupling resonance wireless charging system of an electric vehicle will not harm the human central nervous system in the vehicle.

Keywords: Magnetic Coupling Resonance, Wireless Charging, Electric Vehicle, Electromagnetic Exposure.

P1113

Study on Active Resistance Design Methods for Digital Current Controllers of IPMSM

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To enhance the capability of rejection capability of the back EMF disturbance, active resistance technique is commonly used. In regard to the current values used to implement the active resistance, normally there are two ways, using the present sampled current or using its one-step prediction value. Analysis about the difference between the two typical methods however, has not been found up to date. To fill the gap and to make some theoretical guidance for selection of these two ways, the differences are analyzed carefully and some suggestions are presented to engineers. After that, some potential weaknesses of the two methods are discussed and the possible ways to developing them further are presented. What's more, the analysis is taken in the discrete-time domain directly and suitable for the condition of low carrier ratio. At last, all of the analyses are verified through experiments.

Keywords: Active Damping, Current Control, Discrete-Time Control, Interior Permanent Magnet Synchronous Machines.

P1165

Study on a High-Efficiency DC/DC Converter for a Class of Space Fuel Cell Driving Power

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Aiming at the application requirements of energy management strategies for a type of space fuel cell system, a BUCK circuit, combined with quasi-resonant soft switching methods, current zero-crossing and peak current detection, front-end current detection and other technologies, through improved design and optimization of control methods, to achieve high efficiency driving power available in the aerospace field. A special soft-switching technology is realized, and the input switch tube is turned off and turned on in a single cycle at the peak point and zero-crossing point of the inductor current to reduce the switching loss. Simulate the drive power supply through PSIM to optimize the design of parameters such as operating frequency range and zerocrossing detection. Finally, the principle prototype was developed to verify the control technology. The results of simulation and the principle prototype show the feasibility and high conversion efficiency of the control method.

Keywords: Space, Energy Management Strategy, Current Detection, Single Cycle Control, Soft-Switching Technology.

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P1198

Research on Grid-side Control for a Medium Voltage Direct-Connected Cascaded Inverter Based on Model Predictive Control Under Weak Grid Conditions

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This paper proposes a control method for medium-voltage direct-connected cascaded H-bridge multilevel inverters with model predictive control (MPC) under weak grids. The topology of this inverter and the principle of its finite control set are analyzed in this paper. Based on which, the derivation of the system predictive model is illustrated considering the weak grid. By eliminating the redundant state of the switches, the finite control set is optimized, so the control shortcomings problem of the cascaded multilevel inverter is solved for the traditional model predictive control method which means a big calculation burden and online-implement difficulty. Furthermore, the "calculate before output" method used in the past will cause the actual control output to be delayed, and in order to eliminate the delay, this paper proposes an improved MPC strategy, which introduces a two-step predictive calculation for the grid current control. Finally, the rationality and effectiveness of the proposed method are verified by Matlab/Simulink simulation.

Keywords: Multi-Level Inverter, Cascaded H-Bridge, Model Predictive Control, Weak Grid

P1215

A Fast Switching Superjunction IGBT with Segmented Anode NPN

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In this paper, a fast switching segmented anode npn superjunction (SJ) insulated gate bipolar transistor (SA-NPN SJ IGBT) is proposed. The anode of the device consists of segments of n-col/p and p-col under the n-buffer. The n-col/p-base/n-buffer forms a narrow base npn transistor, which helps electrons to be extracted faster and reduces the turn-off loss (E_{off}). It is demonstrated that the npn transistor could reduce the Eff dramatically at any pillar doping levels. In addition, the effect of different ratio of the anode segments and doping concentration of p-base has also been investigated. Simulation results show that, under on-state voltage drop (V_{on}) of 0.98 V, Eff of the SA-NPN SJ IGBT is as low as 0.74 mJ/cm^2, which is 45% lower than that of the conventional SJ IGBT.

Keywords: insulated gate bipolar transistor (IGBT), Superjunction, Segmented anode, On-state voltage, Turn-off loss.

P1230

Impedance modeling and resonance suppression strategy of voltage source DFIG

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With the rapid development of wind power, the voltage source DFIG (double-fed induction generator) has the ability to actively provide frequency and voltage support under weak grids and has attracted wide attention. However, when it is connected to the parallel-compensated weak power grid, medium and high frequency resonance may occur due to the interaction of the machine and the network. In response to this problem, this paper first establishes a generator-side impedance model of a voltage source DFIG, and analyzes the resonance phenomenon in the parallel compensation grid. Then, based on the control structure characteristics of the voltage source DFIG, a resonance suppression strategy is proposed. Finally, the resonance suppression strategy is verified by simulation.

Keywords: Voltage source DFIG, Parallel compensation weak grid, Impedance model, Resonance suppression.

P1232

Design and Optimization of Modular Multilevel DC Transformer

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Modern science and technology are developing rapidly, the power industry is also developing at a high speed, the traditional transformer is more and more difficult to content the requirement of the power system. Power electronic transformer (PET) is a kind of composite installation composed of power electronic converter and high frequency transformer. It can realize voltage conversion, electrical isolation and energy transmission functions of traditional transformer, and can also control voltage and current in power system and intelligent management. It is the best choice to realize voltage transformation function in modern power system. Compared with the traditional power electronic transformer, a power electronic transformer with lower device failure loss and better output waveform is proposed, the modular multilevel converter (MMC), which has a highly modular architecture.

This essay revolves about the new type of MMC based power electronic transformer in the medium voltage distribution network, which adopts a three stage topology made up of the high voltage input stage, the intermediate isolation stage and the low voltage output stage. The input stage uses the MMC structure, the isolation stage is composed of several input series output parallel (ISOP) double active bridge DC/DC converters, and the output stage uses the traditional three-phase four leg inverter topology. This paper introduces the development process and the development direction of the power electronic transformer in recent years, analyzes and discusses the principle of three parts of power electronic transformer, and expounds the expected experimental results at the end of the paper.

Keywords: PET, MMC, DC Transformer.

P1233

Analysis and Design of Modular Multi-level DC/DC Converter

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Bidirectional DC-DC converter plays an important role in distributed power generation system due to it is necessary to control the power flow between energy storage devices and DC bus. The conventional phase-shifted dual-active-bridge (PS-DAB) converter inherits simple control, symmetrical stricture, and zero voltage switching (ZVS). However, large dv/dt will be created when applied in a high voltage range. Modular multi-level DC transformer (MMDC) originates in the modular multi-level converter (MMC) and dual active bridge (DAB). The MMDC topology can be obtained via displacing the power devices in the primary side of DAB with series-connected submodules. A vital issue to ensure MMDC is operating in a stable state is balancing the capacitor voltage of each submodule in the arm. A capacitor voltage balance method is proposed in this paper. The operating principle is reassigning the gate signals of higher capacitor voltage submodules (SMs) to lower capacitor voltage SMs. According to the simulation results, the capacitor voltage has different outputs. The N+1 level change of each N-SMs-arm balanced when the MMDC starts, which means that EMI and dv/dt are reduced in the transformer pressure.

Keywords: Modular-Mutilevel Structure, Bidirectional DC-DC Converter, Submodule Voltage Balance.

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P1281

Design of Information Management System for Large Modular Manned Spacecraft

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The information management system is an important part of the large modular manned spacecraft. According to the characteristics of the platform, astronaut and experiment data managed by the information management system, this paper puts forward the top-level framework of "Three networks + TT&C". At the same time, combined with the characteristics of multi-cabin combination, the information management system architecture oriented to the combination is designed. The main functions of the platform network, communication network and experiment network are designed, respectively. Finally, the functional subsystems of the TT&C system are summarized.

Keywords: Manned Spacecraft, Information Management System, Network, AOS.

P1299

A Dual-Input High Step-up Photovoltaic Power Optimizer with Integrated Energy Storage

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A new dual-input photovoltaic (PV) power optimizer with integrated energy storage and high voltage gain is proposed in this paper. The features of the proposed optimizer are described as follows: 1) four different duty ratios are used to achieve the maximum power point tracking of the PV sources, the battery power control, and the output voltage regulation, respectively; 2) low input current ripple, which is appropriate for PV application; 3) high voltage gain is achieved by magnetic coupling method; 4) the PV power input sources can provide power to the load and the battery individually or simultaneously; 5) there is no dc current saturation in the core due to the capacitor in the primary winding. The steady-state analysis of the proposed optimizer is studied in detail. Further, the feasibility of the proposed optimizer is verified by the simulation results.

Keywords: Photovoltaic Power Optimizer, High Voltage Gain, Energy Storage, Multi-Input Converter, Coupled Inductor.

P1305

Analysis of the Effect of the Parasitic Capacitance of Switch Devices on Current Distortions of Voltage Source Rectifier

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Deadtime produces current distortion in voltage source PWM converters, especially for high switching frequency PWM converters. The deadtime voltage error considering the effect of parasitic capacitance of switch devices is analyzed. The fast Fourier transform (FFT) of deadtime voltage error within a line frequency period is given. The (6n±1)th harmonic spectrums of the deadtime voltage error with different parasitic capacitances are shown. As parasitic capacitance increases, the (6n1)th harmonics of the deadtime voltage error decreases, thus the current harmonics of three-phase voltage source rectifier (VSR) decreases. Simulation results of the MATLAB/SIMULINK model are given to verify the theoretical analysis of the effect of parasitic capacitance on current distortions of three-phase VSR.

Keywords: Deadtime Voltage Error, Parasitic Capacitance, Fast Fourier Transform (FFT), Current Distortions, Voltage Source Rectifier (VSR).

P1329

Current Harmonic Elimination for Dual Three-phase PMSM Based on Flux Linkage Harmonic Closed-loop Control

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Dual three-phase permanent magnet synchronous motor (dual three-phase PMSM) contain serious current harmonics due to the mutual inductance coupling between the winding sets. In order to solve this problem, this paper proposes an improved method of current harmonic elimination based on vector space decomposition (VSD), which achieves current decoupling control. Compared with direct control of current harmonics in conventional VSD, this method realizes closedloop control of the flux linkage harmonics according to the analytical model of flux linkage. Finally, the simulation results show that the 5th and 7th current harmonics have decreased obviously, which verify the effectiveness of the proposed method.

Keywords: Dual Three-Phase PMSM, Flux Linkage Analytical Model, Current Harmonic Elimination, Flux Linkage Harmonic Closed-Loop Control.

P1331

Analysis and Design Considerations of Improving Power Factor at Light-Load in a CHB Rectifier with Common-Duty Control

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Multi-level CHB rectifier with common-duty-ratio control suffers from low power factor in light-load condition, which related to small boost inductance and insufficient gain of current compensator at line-frequency. In order to solve this problem, a practical design method based on proportional resonant compensator is proposed, which can realize the optimization of power factor under light load. Finally, the effectiveness of the design method is verified by experiments, and the light-load power factor of CHB rectifier is increased to 0.95.

Keywords: Light-Load Power Factor, CHB Rectifier, Small Inductance, Digital Control.

P1337

Wireless Power Transfer System with Ultra-Thin Aluminum Foil

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This paper proposes a special capacitive wireless power transfer (CPT) system with the aluminum foil-based coupling coupler. The aluminum foil is much thinner and lighter than the general metal plates. What's more, it is flexible, cheap, and convenient. Compared with the general coupling capacitor, which is consisted of metal plates, the thickness of aluminum foil coupling capacitor is much thinner. The shape of aluminum foil could be easily built and changed according to the application requirements. This CPT system could be used for the flexible Organic Light-Emitting Diode (OLED) based electronic products. An experimental CPT system is built to demonstrate the theoretical analysis. The experimental results show that the proposed CPT system could work with the air dielectric. The stable load voltage could be achieved, and the 5 W LED lamp is lighted by the proposed CPT system. As a result, the power could be wirelessly transferred by the aluminum foil-based coupling coupler. The theory and design of proposed CPT system are verified by the experimental results. This paper provides opportunities on design and manufacture of CPT system that can solve challenging technological problems for future electronic device applications.

Keywords: Wireless Power Transfer System, Capacitive, Aluminum Foil, Flexible Organic Light-Emitting Diode (OLED), Aluminum Foil.

P1338

Research on Single-stage Cuk Inverter for Photovoltaic Power Generation

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At present, the photovoltaic technology has been widely developed and applied, but the output voltage level of photovoltaic power generation system is still relatively low, and voltage range is wide. Therefore, the traditional bridge type inverter is can't meet the demand.

This paper proposes an improved new Cuk photovoltaic inverter, the new inverter can boost pressure, the dc input voltage has the strong ability to adapt, and is suitable for photovoltaic power generation system. Firstly, this paper introduces the new Cuk photovoltaic inverter topology structure and working principle, and states control mode and working mode of the inverter. Then it analyzes the design of the system parameters. Finally, it uses Matlab/Simulink software to establish the system simulation model, adopts the voltage closed loop control strategy on the system simulation, and produced a test prototype. Simulation and prototype test results show that the improved new Cuk photovoltaic inverter can achieve the function of circuit booster, and is applicable to wide input voltage occasions. So it has important research significance.

Keywords: Cuk Inverter, Photovoltaic Power Generation, Voltage Closed-Loop Control, Simulation, Prototype Test.

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P1349

Research on Measurement Method for Capacitive Current of Distribution Network Based on Signal Injection

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During the operation of large capacity distribution network, it is necessary to measure the capacitive current to match the corresponding arc suppression coil. In order to solve the problem that the capacitive current cannot be measured in the distribution network system whose neutral point is grounded by arc suppression coil, this paper proposes a method to measure the parameters of the distribution network by injecting four different frequency signals from the neutral. This method can measure the distributed capacitance of distribution network when the arc suppression coil is running online. It can automatically detect the operation state of arc suppression coil in distribution network and select different equivalent models for calculation. Theoretical analysis and experiments show that the method has strong adaptability, simple calculation and high measurement accuracy.

Keywords: Capacitive Current, Signal Injection Method, Arc Suppression Coil, Medium Voltage Distribution Network, Four Frequency Method.

P1350

Fault-Tolerant Control Strategy of Dual Three-Level Inverter based on Vector Clamped PWM

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Aiming at solving the switch open-circuit fault of the dual three-level inverter for open-end winding induction motor (OEW-IM), a fault-tolerant control strategy based on vector clamped PWM (VCPWM) is proposed. When the fault is detected, the topology is reconstructed and the phase where the faulty switch is located is clamped to the 'o' level. Meanwhile, combined with VCPWM, one inverter is in the clamped state, while the other inverter performs vector synthesis, so that system switching losses can be reduced. In addition, the method proposed in this paper can achieve the neutral point voltage (NPV) balance in the fault-tolerant process. Simulation results show that the proposed fault-tolerant control strategy can realize the tolerance of the switch open-circuit fault of the dual three-level inverter for OEW-IM.

Keywords: Fault Tolerance, Vector Clamped Pwm, Loss Reduction, Neutral Point Voltage Balance.

P1361

Weighting Factors' Real-time Updating for Finite Control Set Model Predictive Control of Power Converters via Reinforcement Learning

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The selection of weighting factors (WFs) is a common obstacle for the finite control set model predictive control (FCS MPC) of power converters. This paper proposes a generic approach to update the WFs via reinforcement learning (RL). The WFs' selection is self-taught online with full consideration of user-defined requirements. The trained policy is deployed to update the WFs in real-time. The self-taught process can be reactivated anytime in case of parametric variations or load change. This idea is verified on FCS MPC-regulated stand-alone inverters cascaded with LC input filters. Simulation results demonstrate that RL significantly improves the load-voltage tracking accuracy without sacrificing dc-link voltage stabilization.

Keywords: Model Predictive Control (MPC), Reinforcement Learning (RL), Weighting Factors (WF), Inverter Control.

P1375

Accuracy Measuring System for A Resolver and Its Decoder

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In order to use the resolver to obtain the rotor position information of the motor, there are many dedicated decoding chips and soft decoding methods on the market. In order to measure the decoding accuracy of the decoding chip, a 20-bit high-precision absolute value encoder and resolver are installed on the rotor of the motor, and a measurement system is designed to measure the error of the decoder through the high-precision absolute value. First, the working principle of the resolver, the working principle of the AD2S1205 and the peripheral circuit are systematically introduced. The TMS320F28335 is used to analyze the rotor position. Finally, the coaxial high-precision absolute encoder is used to analyze the error of the AD2S1205 decoding result. Experimental results show that the rotor position error analyzed by the AD2S1205 is within the electrical error of the resolver, and the decoding accuracy is high.

Keywords: Resolver, AD2S1205, absolute encoder, TMS320F28335.

P1380

Diagnostic Technique for Inter-turn Faults of PMSMs Based on Search Coils Using High-frequency Negative Sequence Components

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This paper investigates inter-turn short circuit faults of the permanent magnet synchronous machine, and presents a fault diagnosis method based on search coils. A new embedded structure of search coils is designed, and the composition of search coil voltage signal is analyzed. Based on the analysis of voltage PWM harmonic variation, a high-frequency negative sequence component method for the diagnosis of inter-turn short circuit faults is proposed and the fault position can be located.

In this method, the fault information is converted into the twice switching-frequency signal, which is not only beneficial to the design of the filter, but also can avoid the influence of speed variation. Compared with the traditional control method, this diagnosis strategy is more sensitive to inter-turn short circuit faults and less affected by the load. Finally, the effectiveness of the proposed fault diagnosis strategy is verified by an experimental platform.

Keywords: Permanent Magnet Synchronous Motor, Inter-Turn Short Circuit Fault, Search Coil, High-Frequency Negative Sequence Component.

P1390

A Portable Impedance Measurement Device with Controllable Broadband for Power Grid

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In order to avoid grid oscillations caused by the frequency domain impedance mismatch of power electronic devices and power system, this paper studies and designs a controllable broadband power grid impedance measurement device to measure real-time parameters of low-voltage distribution network. The core circuit of this portable device adopts an improved "butterfly bridge" circuit, which reduces the size and weight of the device. The main control unit selects the DSP chip TMS320F28335 of Texas Instruments Semiconductor and one injection can realize widefrequency harmonic excitation. In addition, users can directly generate modulation signals at specific frequency band through touching on the screen, and monitor the process and results of disturbance injection in real time. The final built device has a power of about 5 kVA, has an AC voltage below 400V, and an AC current below 50A sampling capacity. Considering the measuring results, the designed device is efficient in measuring the wide-frequency band impedance for power grid within the set frequency range.

Keywords: Impedance Measurement, "Butterfly Bridge" Circuit, Controllable Broadband, Portable Device.

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P1397

An Overcompensated Design Method for Series-Series Compensated Wireless Power Transfer Systems

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The most widely used wireless power transfer (WPT) system is Series-Series (SS) compensated topology driven by a full-bridge or half-bridge inverter. In order to achieve zero-voltage switching (ZVS), the switching frequency of inverter should be above the resonant frequency so that it is not on themaximum efficiency point of coils. This paper provides a mathematical analysis of the ZVS condition and the efficiency characteristic of SS compensated WPT systems. An overcompensated design method for SS compensated WPT system is proposed in this paper, which can achieve the ZVS condition and the maximum transfer efficiency at the same time.The simulation and experimental results validate the design method. The measurement efficiency of the WPT prototype can reach above 90% over a wide operating range from 16% load to full load.

Keywords: Zero-Voltage Switching (ZVS), Wireless Power Transfer (WPT), Overcompensation.

P1424

An Improved Model Predictive Control of Virtual Synchronous Generator for an Islanded AC Microgrid

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The typical finite-set model predictive control (FS-MPC) scheme for LC-filtered voltage source inverters (VSIs) lack inertia and damping, and the output current is easy to exceed the limit under the load-step change. Meanwhile, since the current sensor is needed to measure current information, the hardware cost is increased.

To resolve these problems, an improved model predictive control combined with a virtual synchronous generator (MPC-VSG) is proposed in the paper. Above all, an MPC with a multi-objective cost function (CF) is used to minimize the tracking voltage error while providing overcurrent protection. Then, to provide the inertia and damping needed by the system, a VSG scheme is employed to generate voltage reference. Besides, a Luenberger observer is utilized to observe the inductor current. In this way, the number of current sensors is reduced to save the hardware cost. Finally, some comparative simulation experiments in Simulink verify the effectiveness of the improved MPC-VSG.

Keywords: Model Predictive Control, Multi-Objective Cost Function, Virtual Synchronous Generator, Current State Observer.

P1005

Research on Improving the Fault Simulation Accuracy of Modular Multilevel Converters

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The digital real-time simulation-based function and dynamic performance tests of the modular multilevel converter (MMC) control and protection systems have become an important method to ensure the safety and reliability of the MMC-HVDC projects, of which the real-time simulation model of the MMC is one of the key factors affecting the test effect. Currently, the MMC models are generally implemented in the central processing unit (CPU) and field programmable gates array (FPGA) with multi-rate time steps (large-small time step simulation). In case of fault simulations, the loss of accuracy caused by communication delay between CPU and FPGA can be significant. In order to further improve the test performance, the FPGA based small time step model of MMC has been studied. Comparative simulation has been carried out under AC and DC fault conditions to verify the proposed method. The results show that the real-time simulation accuracy of the MMC can be effectively improved with the new method.

Keywords: Modular Multi-Level Converter, Real Time Simulation, Small Time Step Model.

P1016

Half Bridge LLC resonant Converter Design for Wide Input Voltage Range Applications

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This manuscript explain the design of half bridge LLC resonant converter for extensive input voltage range applications with high efficiency in normal mode and high voltage gain during hold-up time. Usually, to minimize the primary circulating current and lower conduction losses, large magnetizing inductance is used. Still, when a large magnetizing inductance is designed, it is difficult to adjust output voltage for a wide input voltage range. Therefore, in this paper, an auxiliary inductor and a switch is used in parallel with a magnetizing inductor to change its value according to the input voltage. During normal operation high magnetizing inductance is used for high efficiency and lower conduction losses, when the input voltage is dropped to its minimum value, smaller magnetizing inductance is used to acquire high voltage gain and increase the hold-up time duration. With the auxiliary inductor and a switch, the converter can achieve high efficiency for Normal mode and high voltage conversion ratio during hold-up time. The proposed method is confirmed through MATLAB simulation.

Keywords: LLC Resonant Converter, Hold-up Time, Wide Input Voltage.

P1018

Analysis and Optimal Parameter Selection of Full Bridge Bidirectional CLLC Converter for EV

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Resonant converters, especially the full-bridge bidirectional CLLC resonant converter, has obtained greatly attention due to its advantages of achieving high efficiency and high power density with operating at high frequency. However, the resonant tank is more complicated, which results in great impediments in optimally designing the resonant tank parameters. In this paper, an simplified design method of resonant tank based on fundamental harmonic approximation (FHA) is adopted.

In detailed analysis and optimal resonant converter such as voltage gain characteristic, zero voltage switching (ZVS) restriction and device stress analysis. Finally, a 1.2 kW prototype is built, and the experimental results verified the proposed method.

Keywords: Bidirectional, CLLC, FHA, Resonant Tank, ZVS.

P1019

Charge-biased Synchronized Triple Bias Flip Circuit for Piezoelectric Energy Harvesting

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This paper implements parallel synchronized triple bias-flip (P-S3BF) interface circuit for piezoelectric energy harvester based on general synchronized multiple biasflip model. By increasing the efficiency of the interface circuit, it is expected that under given piezoelectric device and load resistor, more energy can be harvested by the piezoelectric energy harvesting system. This paper also gives a detailed analysis of the circuit operation principle. Simulation results proved that P-S3BF outperformed standard energy harvesting (SEH) circuit. Voltage across the load resistor and energy harvested on the load resistor are 223% and 497% higher on P-S3BF compared to SEH, respectively. Besides, the control method proposed in this paper is simpler than the original control method. An extensive space in the SMBF model circuit area can be expected if significant performance increase is achieved with SMBF circuit after the control method is simplified and the whole circuit become more integrated.

Keywords: Piezoelectric Energy Harvester, Interface Circuit, Synchronized Multiple Bias-Flip.

P1027

Multi-objective Optimization Design of Spherical Induction Motor

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In order to improve the overall electromagnetic performance of spherical induction motors, a multi-objective optimization design method combining the response surface method and particle swarm optimization was proposed, aiming at the two key optimization objectives of motor starting torque and torque ripple. Firstly, this paper introduces the basic structure and operation principle of spherical induction motor. Then, the effective design parameters and their ranges are selected to establish the optimal response surface model, and the optimal parameters are obtained by particle swarm optimization (PSO) algorithm. Finally, the finite element analysis of the motor scheme before and after optimization is carried out to verify the effectiveness of the multi-objective optimization method.

Keywords: Spherical Induction Motor, Multi-Objective Optimization, Finite Element Analysis, Response Surface Model, PSO.

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P1036

Analysis of the Influence of Voids in Solder Layer on IGBT Failure based on ANSYS

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The temperature field distribution of IGBT module will be inevitably affected by the unavoidable void of solder layer in IGBT module packaging, which will seriously affect the thermal stability. In order to reduce the influence of the void in the encapsulation of IGBT module, the IGBT failure process is analyzed based on ANSYS. In this paper, a three-dimensional model of the IGBT module is established. Then, the influence of solder layer void on the temperature distribution of IGBT module under different sizes and positions is studied based on ANSYS. The results show that under the same void ratio, the void on the top corner of the solder layer has the greatest impact on the junction temperature of the IGBT module. Besides, at the same position, the maximum junction temperature of the IGBT module increases linearly with the increase of the void ratio on the solder layer.

The simulation results have guiding significance for improving the thermal stability of IGBT modules.

Keywords: IGBT, ANSYS, Thermal Simulation Analysis, Solder Layer Void.

P1040

Reliability Modeling and Simulation Analysis of IGBT Devices based on Saber Software

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An IGBT reliability model based on Saber software which can reflect the aging process of IGBT is proposed in this research in order to better reflect the changes of multi-feature values in IGBT reliability model. At first, the coupling relationship among electrical, thermal and mechanical of IGBT is deeply analyzed, and then an IGBT reliability evaluation model based on Saber software is established according to the failure mechanism of IGBT bond line, and its static and dynamic characteristics are verified. The simulation results are in good agreement with the experimental results. The effects of collector current I_c and gate driving voltage U_{ge} on the saturation voltage drop of IGBT are verified by the built model. The conclusions are as follows: 1) the saturation voltage drop increases continuously with the deepening of the aging degree of IGBT. 2) the saturation voltage drop is affected by the collector current and driving voltage passing through IGBT. The study of this model has a certain guiding significance for realizing the reliability evaluation of IGBT and improving the reliability of power electronic power conversion devices.

Keywords: IGBT, Reliability Model, Simulation Analysis, Saber.

P1050

A Research on Inductance Forcedly Absorbing Current to Reduce Stray Current in Metro

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The stray current of metro corrodes the buried metal pipe, line and steel structure greatly. To inhibit the flow of stray current into the ground, an inductive force current absorption circuit (IFACC) is analyzed in this paper. It makes the traction current flow back to the traction substation through reflux current wire (RCW) to reduce rail potential, so as to achieve the purpose of inhibiting the stray current leakage. On this basis, the three-layer return flow model of "rail-buried metal-earth" is designed. Based on the circuit mathematical model, we analyzed the working principle of IFACC and the stray current. And The function of IFACC is verified by MATLAB simulation and low voltage experiment. The research results show: it is in the traction power supply system equipped with IFACC that the current flowing through the rail is significantly reduced, and most of the backflow is carried out through the RCW. It is verified that IFACC has a good effect of inhibiting stray current.

Keywords: Stray Current, Reflux Current Wire, Inductance Forcedly Absorbing Current, Traction Power Supply System.

P1056

Degradation Assessment of Photovoltaic Module Based on Probability Distribution Analysis of Model Parameters

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In recent years, the intelligent operation and maintenance of the photovoltaic (PV) systems attracts much more attentions. The prognosis and health management of PV array is a critical part of this issue. The conventional degradation prognosis approaches attempt to predict the degradation ratio based on the measured historical power of PV array and the meteorological data. In this paper, the long term measured current-voltage (I-V) characteristic data of the PV module are used to extract the electrical and model parameters for the detail analysis of the degradation of the PV module. The probability distribution of the model parameters under different irradiance levels are investigated.

Hopefully, the performance degradation trends of the PV module can be further prognosed by assessing the probability distribution trends of the extracted parameters.

Keywords: Photovoltaic Module, Degradation Assessment, I-V Characteristic, Probability Distribution, Model Parameter.

P1063

Adaptive Terminal Sliding Mode Control for Magnetic Levitation System With Observer

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In order to improve the convergence rate and disturbance reject ability of magnetic levitation system, this paper proposes an observer-based adaptive non-singular terminal sliding mode controller. Firstly, the dynamical model of magnetic levitation ball system is deduced, Then on the basis of the sliding mode control (SMC), an adaptive non-singular terminal sliding mode control(ANTSMC) is constructed. The ANTSMC can speed up the convergence speed and reduce chattering. In order to enhance the anti-interference ability, state estimation are cooperated into ANTSMC by using state observer. The simulation results confirmed the closed-loop magnetic levitation system performance both in dynamic response and disturbance attenuation, corresponding quantitative comparison could also show the advantages of proposed control scheme.

Keywords: Magnetic Levitation Ball System, Non-Singular Terminal Sliding Mode Controller, Adaptive Controller, Observer.

P1067

Optimization of Magnetic Coupling Resonance Coils

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In some practical applications of low-power coupled resonant wireless power transmission, besides the transmission efficiency, the anti-radial offset ability of the transceiver coils is also an important parameter to measure system performance. Consider that the positive correlation between the transmission efficiency and coupling coefficient of the coils, the symmetrical double-layer circular coils structure is proposed under the condition of maximizing the coupling coefficient in this paper. Based on the finite element method, the Maxwell simulation software is used to analyze different models. Simulation shows that the double-layer structure which reduces the number of outer layer turns can improve the coupling coefficient and the ability to resist radial offset both. It provides an idea for improving the system transmission efficiency and anti-radial offset ability both.

Keywords: Wireless Power Transmission, Double-Layer Circular Coil, Anti-Radial Offset Ability, Maxwell.

P1074

Capacitive Coupling Wireless Energy Transmission Constant Voltage System Based On Composite Network Resonance

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Electric field coupling wireless energy transmission is a way of transmitting electric energy wirelessly through a high-energy electric field as the energy medium. In actual application scenarios, the load situation is complex and changeable, and the static load has great limitations. In the case of load changes, the system can still provide a stable voltage power supply has become a top priority. Based on this idea, this article designed a capacitive coupling impedance matching structure that can keep the system stable under dynamic loads. Finally, the feasibility of capacitive coupling power supply was verified through simulink, and through the establishment of an experimental model, the energy transmission of 6W can be completed under a load of 10′, and the transmission efficiency can reach 80%.

Keywords: Capacitive Power Transfer, Impedance Matching, Dynamic Load, Constant Voltage.

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P1084

Inverter Fault Diagnosis Based on Optimized BP Neural Network

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The inverter fault diagnosis based on BP neural network can fall into local minimum and overfitting. To solve these problems, we propose a fault diagnosis method based on BP neural network optimized by cross entropy and L2 regularization. In this proposed method, the quadratic cost function is replaced by the cross entropy cost function, which avoids the influence of the partial derivative of the activation function. L2 regularization is used to adjust network toward the small weight distribution. This method reduces the possibility of falling into local minimum and overfitting. The experimental results show that the optimized neural network can improve the accuracy of inverter fault diagnosis.

Keywords: Inverter Fault Diagnosis, BP Neural Network, Cross Entropy, L2 Regularization.

P1087

Research on Honeycomb Multi-Station Integration System

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In order to solve the challenging problem of the current distribution network operation caused by the massive access of distributed generation and electric vehicle charging piles, a honeycomb multi station fusion system is proposed in this paper. Firstly, the topology and key equipment of the multi-station integration system are analyzed, and then the hierarchical structure of the honeycomb multi-station integration system applied to the distribution network is studied. The hierarchical structure topology, networking mode and power grid architecture of multi-station integrated distribution network are discussed. Finally, the challenges faced by the future distribution network based on the new mode of multi-station integration are analyzed in terms of industry barriers, economy and reliability, multi time scale and multi spatial dimension energy interconnection, etc.

Keywords: Distribution Network, Honeycomb Topology, Multi-station Integration, Network Mode, Hierarchical Structure.

P1092

A Neutral-Point Potential Balanced Deadbeat Direct Torque Control Strategy of Post-Fault Three-Level NPC Inverter-Fed Induction Motor Drives

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This paper proposes a deadbeat direct torque control strategy that can suppress the fluctuation of the neutral-point potential (NPP) of the DC bus for the induction motor (IM) system driven by the eight switch three phase inverter (ESTPI). The proposed strategy calculates the torque angle based on the deadbeat control of torque and stator flux, and reference voltage vector is calculated by the discrete stator voltage equation. According to the load current and the NPP, different pairs of small vectors are selected to synthesize a virtual zero vector, thereby implementing NPP control. The proposed control strategy not only achieves the accuracy of torque and stator flux control, but also suppresses the NPP fluctuation. Effectiveness of this method has been validated by simulation results.

Keywords: Eight-Switch Three-Phase Inverter, Deadbeat Direct Torque Control, Neutral Point Potential, Virtual Zero Vector.

P1096

Adaptive Tuning of Phase-Locked Loop Parameters for Grid-Connected Inverters in Weak Grid Cases

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For grid-connected inverter, phase-locked loop (PLL) is a common method to synchronize the output current with the grid voltage. However, in weak grid, as the grid impedance cannot be ignored, the inverter tends to be unstable. Besides, the grid impedance can vary in the actual application, using fixed PLL parameters designed for specific grid condition cannot guarantee the inverter robustness against the grid impedance varying. Hence, this paper aims to propose an improved method to improve the typical single-phase delay-based PLL. At first, the impedance model of the inverter is established and the reason for the system stability deterioration is analyzed in detail. Then, an adaptive PLL is proposed based on the quasi-passive method for grid-impedance measurement. The PI parameters of the PLL have been adaptively adjusted online according to the measured grid impedance so as to achieve the high phase margin (PM, not less than 40°) in the weak grid. Simulation results have proved that the proposed adaptive PLL can ensure the system stability, maintain the high quality of grid current and robustness in the weak grid.

Keywords: Grid-Connected Inverter, Phase-Locked Loop, Weak Grid, Robustness, Adaptive Tuning.

P1106

Analysis of Fault Detection Based on Least Squares Approach for BDS Integrity Monitoring

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BDS receiver autonomous integrity monitoring plays an important role in avionic navigation system. In this paper, RAIM algorithm based on least squares approach is discussed. Least squares approach is used to detect and identify the fault satellite by the pseudo-range residual construction test statistics. The availability analysis of fault detection based on least squares approach of BDS single system is researched. The results show that the RAIM algorithm based on least squares approach can successfully detect and identify the fault satellite. After using the RAIM algorithm to eliminate fault satellite, it can be clearly seen that the positioning accuracy returns to a fault-free state. Moreover, the RAIM algorithm based on least squares is extremely important for the study of BDS satellite navigation and aviation user life safety.

Keywords: BeiDou Navigation Satellite System(BDS), Receiver Autonomous Integrity Monitoring(RAIM), Least Squares(LS), Fault Detection.

P1124

Research on the Degradation Characteristics of IGBT Safe Operation Area(SOA) in Traction Converter

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IGBT is the core part in traction converter,its performance directly affects the design characteristics of the converter. Ensure IGBT works in its own safe operation area (SOA) can improve the reliability of traction converter, decrease failure rate and extend service life. Based on the aging mechanism of traction converter IGBT, this paper studies on the degradation of boundary characteristic parameter of IGBT safe operation area(SOA), which include maximum collector continuous current I_{CDC}, maximum collector power consumption P_{cmax} and short-circuit saturated current $I_{SC,sat}$, buliding the dynamic models of DC safe operation area (DCSOA) and short circuit safe operation area (SCSOA) in IGBT life cycle. this model has certain theoretical significance and application value for IGBT condition monitoring.

Keywords: IGBT, Aging, Safe Operation Area (SOA).

P1134

A Voltage Differential and Pulse Synchronous Driving Control of Paralleled IGBTs for Current Balance Improving

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In high-power applications, when the current capacity needs to be further expanded, the method of using insulated gate bipolar transistors in parallel is usually used. However, due to the influence of parasitic parameters, the current of each branch of the paralleled IGBTs may be imbalanced. The imbalance of dynamic and static currents can cause overheating and overcurrent damage to the device. This paper studies a driving method that uses differential gate voltage and synchronous pulse to improve the current imbalance during the turn-on process of paralleled IGBTs. The effectiveness of the strategy is verified by simulation. The experimental results show that the voltage differential and pulse synchronous driving method can effectively reduce the dynamic current imbalance between paralleled IGBTs.

Keywords: High Power Igbts, Paralleled Connected, Dynamic Current Balance, Voltage Differential And Pulse Synchronous.

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P1135

Study of The Power-Load Characteristics in A Widely Adapted Driver Circuit for Several Types Power Semiconductor Device

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The drive circuit plays a key role in exerting the characteristics of power devices. For devices of different materials and processes, the output voltage amplitude of the drive circuit is very different. Aiming at the power supply problem of the driving circuit of various types of devices, this article focuses on studying a power supply type that can meet the different power supply standards of the driving circuit. First, the load characteristics of the driving power supply are analyzed, and the gate voltage and driving power of different devices are compared. Secondly, the design method of flyback circuit is introduced in detail, including the selection of magnetic core and the design of inductance. Finally, the Pspice simulation software was used to test the output voltage waveform of the power supply, and the rationality of the circuit was verified through experiments.

Keywords: Power Semiconductor Devices, Power-Load Characteristics, Different Material Devices, Multiple Windings.

P1140

Research on Fault Diagnosis and Reconfiguration Strategy of Single-Phase Three-Level Cascaded Inverter

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With the rapid development of power electronics equipment, multi-level inverters have attracted much attention due to their good performance, and three-level inverters are the most basic structure. Aiming at the problem of high failure rate, this paper proposes a fault diagnosis and reconfiguration strategy study for single-phase three-level cascaded inverters. By collecting bridge arm voltage and mode lock, the fault signal is output stably to realize fault diagnosis. Combined with the fault diagnosis results, setting the redundancy performance of the corresponding modules and adjusting the control modulation strategy can achieve system reconfiguration. The system still has good harmonic characteristics during faulttolerant operation.

Keywords: Three-Level Cascades Inverter, Fault Diagnosis, System Reconfiguration.

P1144

Research on Dead Time of Half-Bridge LLC Resonant Circuit Based on SiC MOSFET

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As the third generation semiconductor with wide band gap, SiC MOSFET not only has fast switching speed and better switching characteristics, but also has certain efficiency in the converter. LLC resonant converter has been widely concerned as an efficient DC-DC converter. SiC MOSFET is used as the primary side switch of half-bridge LLC resonant converter to further improve the efficiency of the converter. Zero voltage switching can reduce the loss and improve the efficiency of half-bridge LLC resonant converter. This paper analyzes the influence of dead time on zero voltage turn-on, and calculates the critical dead time. The switching performance of SiC MOSFET was tested by setting up a dual-pulse experimental platform. By setting up a half-bridge LLC resonant converter, different dead time was set for comparative experiments. The experimental results show that the dead time is too large to achieve zero voltage switching.

Keywords: SiC MOSFET, Switching Characteristic, Dead Time.

P1149

Diagnosis of Open Circuit Faults for Three-Phase Three-Level Converters Based on the Change Rate of Current Residual

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To realize the diagnosis for IGBT open-circuit faults in a three-phase three-level rectifier, a fault diagnosis based on the change rate of current residual is proposed. Firstly, a mixed logic dynamic(MLD) model of the rectifier was established to generate the residual of the grid current. And then, combining the theoretical calculation with the simulation results, the change rate of current residual and the residual characteristics for different IGBT faults were analyzed. Then, the normalized diagnostic variables and the threshold were defined to accomplish fault detection for the single IGBT open-circuit faults in different situations.

Finally, the validity of the diagnostic method was verified through MATLAB/Simulink simulation.

Keywords: Three-Phase, Three-Level, Rectifier, Fault Diagnosis, Mixed Logic Dynamic Model, The Change Rate of Current Residual.

P1151

The Single-Phase Virtual Synchronous Machine Control Strategy of the Advanced Co-phase Traction Power Supply System

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The traction power supply system is a significant part of the railway system, which is responsible for supplying power to the electric locomotives. The advanced co-phase traction power supply system (ACTPSS)can eliminate all the neutral sections which exist in the traditional power supply system to realize the integral connection of the traction network. The single-phase virtual synchronous machine (VSM) control strategy, which can be applied to the ACTPSS, is studied in this thesis to improve the stability and reliability of the ACTPSS.

Then, the simulation model is built based on the Matlab/Simulink and small-scale experiment platform is built based on FPGA to verify the performance of the single-phase VSM. The results are consistent with theoretical analysis, which prove the correctness and feasibility of the strategy.

Keywords: ACTPSS, Single-phase cascaded inverter, VSM, Matlab, FPGA.

P1170

Research on DC-DC Converter for High Speed Train Auxiliary Power Supply System

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According to the operating environment and requirements of high-speed train, the topology of the full-bridge LLC resonant converter is selected. The mathematical model is established based on the fundamental wave analysis method, and the resonant parameters are designed. A resonant capacitor voltage control strategy is designed, and the correctness of the parameter design and control strategy is preliminarily verified by MATLAB/Simulink simulation.

Keywords: LLC Resonant Converter, FHA, Resonant Capacitor Voltage Control Strategy, MATLAB/Simulink.

P1172

Measurement and Control System of Pulse Power Supply Based on HTSPPT

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In order to monitor the dischargecharacteristics of the pulse power, control the pulse power reliable operation, the pulse power supply control system based on high temperature superconducting pulsed power transformer (HTSPPT) was designed by using modern test technology, virtual instrument and database technology. The system is comprised of single-chip, drive circuit board, voltage and current sensor, data acquisition system and computer. The software uses LabVIEW, ActiveX Date Objects (ADO) technology was used to realize the data interaction between LabVIEW and database, and realizes the storage and query of large amount of data. In this paper, the pulse power supply of two modules synchronous and asynchronous triggering HTSPT is measured and controlled. The experimental results show that the system can accurately trigger the turn-on and turn-off time of IGBT and thyristor and control the discharge of pulse power process. From the synchronous triggering, we can accurately measure the instantaneous current with the half peak pulse width of 1.33ms and the Instantaneous load current peak value of 6.622kA. The voltage of the auxiliary capacitor is 883V. From the asynchronous cooperative triggering, the half peak pulse width is 2.866ms, the peak value of the Instantaneous load current is 4.233kA and the voltage of auxiliary capacitor is 1.1kV.

Keywords: Drive Circuit, Data Acquisition, Pulse Power Supply, Measurement and Control, LabVIEW Introduction.

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P1182

Thermal Analysis of Press-pack IGBT in Hybrid DC Circuit Breaker

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Press-pack insulated gate bipolar transistor (PP IGBT) is the key component in hybrid direct current circuit breaker (DCCB), due to its fast-breaking speed and large interruption capacity. This paper presents the transient behavior of PP IGBT under rated and fault current interruption conditions. For the purpose of evaluation for thermal behavior of PP IGBT, the power losses under different interruption conditions are analyzed, then the cauer model and FEM model are built based on a 4500V/115A press-pack IGBT for junction temperature estimation. Consequently, analytical investigation in conjunction with cauer thermal network model and FEM simulation demonstrate the thermal behavior of PP IGBT under different DC interruption conditions.

Keywords: Thermal Behavior, Power Losses, Press-Pack IGBT, DC Interruption Condition, Cauer Model, FEM

P1184

FPGA Controller Based Bidirectional CLLC Resonant Battery Charger

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The isolated bidirectional resonant converter is widely applied for renewable energy battery charger because of its high operating frequency and power density. But traditional LLC converter has many problems in reverse working mode. This paper introduces the CLLC resonant converter into the battery charging and discharging system.

The circuit principle and the equivalent model of CLLC resonant converter is analyzed and constructed by FHA method. The CLLC battery charger control strategy is realized by FPGA. Based on the theoretical analysis, the resonant network parameters are designed. Finally, the experimental hardware platform of CLLC resonant converter is designed to verify the feasibility of the overall system.

Keywords: Renewable Energy, CLLC Battery Charger, FHA Method, FPGA.

P1199

Design and Comparison of High-Order Output Filters for Grid-Connected Converters with Low Switching Frequency

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For a grid-connected converter, the output filter is probably one of the heaviest and bulkiest components. As the power rating continues to rise, the switching frequency is quite limited and the size of the output *L* filter can increases a lot. It is challenging to design the output filter with small size. It has been a consensus for researchers and engineers that high-order filters are more suitable than the conventional *L*-type filter because they exhibit higher attenuations of switching harmonics even at low switching frequencies. However, among so many kinds of high-order filters, it can still be unclear which one is more suitable for high-power converters with low switching frequencies. Hence, in this paper, three high-order output filters (i.e., *LCL*, *LLCL*, *LCL - LC*) are selected and designed for 4 MW grid-connected inverter, by considering the variations of filter parameters. Especially, in the view of minimizing the total stored energy, the comparisons of different high-order filters are emphasized. It is shown that a higherorder filter may not always have a lower value of stored energy and the *LLCL* filter can realize the lowest stored energy among the discussed high-order filters.

Keywords: Grid-Connected Converter, *LCL* filter, *LLCL* Filter, *LCL - LC* Filter, Design, Harmonic Attenuation.

P1201

Research on Predictive Direct Power Control of Three-phase Separated Hybrid Power Electronic Transformer

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In recent years, power electronic transformers (PET) that can convert electrical energy have been a research hotspot. In order to better adapt to the requirements of smart grids and high-power applications, a hybrid power electronic transformer (HPET) and its control method are proposed. Firstly, a mathematical model based on the topology of the hybrid power electronic transformer is established. Then a predictive direct power control strategy is designed according to the expected goal. Finally, simulation in MATLAB/Simulink verifies the effectiveness of the proposed control strategy.

Keywords: Hybrid Power Electronic Transformer, Predictive Direct Power Control, PI Control, Energy Bidirectional Transmission.

P1246

Research on Voice Coil Motor Control Considering Interference

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This paper discusses the influence of external interference on voice coil motor, establishes a mathematical model of voice coil motor, and proposes the state space equations of voice coil motor that meet the requirements of affine system. On this basis, three-closed-loop PID controller and active disturbance rejection controller are designed. Modelica simulation language is used in the MWorks software to simulate the modeling and controllers. The simulation results show that the active disturbance rejection controller can better adapt to interference and has better frequency response and control quality.

Keywords: Voice Coil Motor, Affine System, Interference, Active Disturbance Rejection Controller (ADRC), PID.

P1261

Research on Symmetrical Switched Capacitor Multilevel AC-AC Converter

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Multi-level AC-AC converter has the advantages of reducing switch voltage stress, adapting to high voltage input and reducing waveform distortion. In this paper, a symmetrical switched capacitor multi-level (SSCML) AC-AC converter is studied. The switched capacitor (SC) technology is introduced into the AC-AC converter, which has the advantages of small size, high efficiency and high power density. Firstly, the topology of SSCML AC-AC converter and its control strategy are introduced. Then, the working principle of the topology is analyzed, and the relationship between input voltage and output voltage is derived in detail, as well as the expression of switch voltage stress. Finally, a 300W prototype is built to verify the proportional relationship between input voltage and output voltage. The prototype and experimental results prove that the multi-level AC-AC converter using SC technology has the advantages of small size and low voltage stress. The experimental results also prove that the voltage stress is proportional to the modulation ratio, which is the key to reducing the voltage stress.

Keywords: Multi-Level AC-AC Converter, Switched Capacitor, Low Voltage Stress.

P1264

Analysis and Implementation of Input Parallel Output Parallel DAHB DC-DC Converters with Sensorless Current Sharing Control Strategy

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The isolated bidirectional converter dual active half-bridge (DAHB) DC-DC converter consists of two half bridge converters and a high frequency transformer.

The DAHB converter has significant features such as high dynamic response, high voltage gain, and zero-voltage soft switching. The series parallel combination of low voltage and small capacity DC-DC converter is a typical scheme to improve the voltage and power level of the converter. However, the complexity and cost increase due to too many current sensors. In view of the current sharing problem in the power module cascaded structure, this paper employs a single phase shift-based sensorless current sharing method for input-parallel output-parallel (IPOP) connected DAHB converter. The converter is analyzed and a 500W IPOP experimental prototype with 50V input voltage and 200V output voltage under 20kHz switching frequency is implemented to verify the theoretical results. Finally, a comparative analysis is given to demonstrate the superiority of the proposed current sharing strategy.

Keywords: Sensorless, Current Sharing Control, Input-Parallel Output-Parallel, Dual Half-Bridge, Bidirectional DC-DC Converter.

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P1268

High Power Driving and Control of Electrical Cylinder in Aerospace Erection System

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Aerospace erection system is used to set up space aircraft launching platform, pulling the space aircrafts from horizontal to vertical position. Due to the large weight of aircraft, hydraulic cylinder is generally used as the actuator. However, it suffers from weak maintenance and environment adaptability, which leads to high fault rate during lifespan. As the development trend of all-electric drives, electric cylinder is generally getting matured and ready to replace conventional hydraulic solutions. In this paper, a high power electric cylinder with multiple servo motors in parallel is researched in details, especially focusing on the high power driving circuit design and start control strategy with heavy-duty in horizontal position. Firstly, the working principle of proposed electric cylinder system is explained. After that, the driving circuit is discussed in details to achieve multiple channel synchronous driving at the same time. Moreover, the heavy-duty start control of motors is put forward to achieve stable and safe launching process.

Based on the techniques above, it is expected to provide a safe and high efficiency method for electric cylinder driving and control.

Keywords: Erection System, Electrical Cylinder, High Power Driving, Start Control Strategy.

P1275

A Voltage Balancing Circuit Based on LC Unit with Dual LC Resonant Tanks

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For the balancing circuit based on three-resonantstate LC unit, the energy transfer between cells cannot be carried out in the self-resonant state, which reduces the balancing speed. To overcome this problem, this paper proposes a voltage balancing circuit based on LC unit with dual LC resonant tanks. The proposed balancing circuit is composed of a LC unit with dual LC resonant tanks and a switch network. By alternately connecting two LC resonant tanks with imbalanced cells, each state of the proposed balancing circuit can transfer energy between cells, which improves the balancing speed. Meanwhile, the zero-current switching (ZCS) of the switch is implemented. Simulation results are provided to verify the validity of the proposed balancing circuit. The results show that the proposed balancing circuit has higher balancing speed than the balancing circuits with three-resonant-state LC unit.

Keywords: Cell Balancing, Voltage Balancing, Zero-Current Switching, Resonant Converter.

P1290

Smart Power Supply System Based on Parallel DC-DC Modules

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With the concept of "Smart City", "Internet Plus" and "Smart Grid" being proposed, the shortage of traditional power supply system is gradually appearing. Traditional power supply system is difficult to organize and manage in batches. Once a power supply malfunctions, the whole power supply system will be out of control. This paper presents a smart power supply system based on distributed parallel module power supply. This system is composed of parallel converter module, control bus and controller. It can smartly adjust the number of enabled modules according to the load power to ensure that each converter module is working in the optimal efficiency range. In this paper, CAN bus protocol is used to communicate among the modules, master-slave current sharing model is used to realize the current sharing between each module; Besides, the efficiency of the converter is optimized by the controller. At the end, the simulation using software has been developed to verify the feasibility and superiority of the proposed method.

Keywords: Smart Power, CAN Bus, Power Module, Optimal Efficiency.

P1317

Voltage Balance Evaluation Strategy after DC-port Fault in Centralized Aircraft Ground Power Unit Based on Three-Level Neutral Point Clamped Cascaded Converter

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The Aircraft Ground Power Unit(GPU) could replace the Auxiliary Power Unit (APU) in the aircraft while the aircraft is parking in the airport. Therefore, the oil-consuming and the air pollution of the APU are solved. However, the GPU is faced with the challenges of utilization, power quality, and fault-tolerance. Thus a novelty centralized aircraft GPU based on a three-level neutral point clamped cascaded converter (3LNPC-CC) is introduced to improve the utilization and power quality. Furthermore, an evaluation voltage balance strategy is proposed for the DC-port fault-tolerance of the 3LNPC-CC. Additionally, the modulation of phase shift pulse width modulation (PSPWM), and the control of double closed-loop are used in the 3LNPC-CC respectively. The simulation including the control, modulation, and fault-tolerance of the system is established to verify the feasibility and the performance itself, especially on the evaluation voltage balance strategy for the DC-port fault. Moreover, a prototype of the GPU and the relevant experiment is completed to verify the correctness and feasibility of the system and the strategy.

Keywords: 3LNPC-CC, Centralized Aircraft GPU, DC-Link Voltage Balance, Evaluation Voltage Balance Strategy.

P1328

A Backpropagation Neural Network Controller Trained using PID for Digitally-Controlled DC-DC Switching Converters

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In this paper, a backpropagation (BP) neural network controller trained using PID for digitally-controlled DCDC switching converters is proposed to improve the transient response performance. To reduce the hardware cost and power consumption, only one BP neural network controller is used in the proposed controller, which is trained to learn the PID control algorithm and obtain the optimal control coefficients to fit the input-output relationship adaptively under different operating points. Furthermore, the proposed controller uses a singlehidden-layer BP neural network to reduce the computing time. Then, a buck DCDC switching converter with the proposed controller is designed and realized on the field programmable gate array and printed circuit board. The experimental results indicated that it yields a better transient performance in a DCDC switching converter than does a conventional neural network PID controller that contains two sub-controllers: the settling time is improved by at least 50% and the hardware resources required for a PID compensator are saved.

Keywords: Intelligent Control, BP Neural Network, DCDC Converters, PID Control, Transient Performance

P1345

Design and Fabrication of Monolithic Light Triggered Thyristor

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Light triggered thyristors (LTT) have attracted considerable attention because of their high insulation of the main circuit and the control circuit, good trigger characteristics, and high reliability. In this work, we propose and fabricate a high-power LTT with monolithic and direct-triggering structure design, triggered by infrared light with a wavelength of 940 nm. The device structure is simplified, and the step by step drive is changed to direct drive, which further improves the response speed. By improving the cathode metal structure, changing from a large area of cathode metal coverage to an interdigitated cathode structure, thus the light injection window area is increased. A reasonable cathode shorts distribution is choosed for the interdigital cathode structure to ensure [dV/dt] tolerance. The test results show that the forward repetitive peak voltages (V_{DRM}) and reverse repetitive peak voltages (V_{RRM}) of the device are all higher than 900V, the rise-time (T_{rise}) is as short as 2.3μs, the [dV/dt] tolerance is larger than 1000 V/μs, and the maximum optical trigger power is as low as 7 mW/cm^2. This upgraded LTT will be widely used in power electronic circuits because of its excellent characteristics.

Keywords: Light-Triggered Thyristor, Vertical Structure, Direct Triggering, dV/dt.

P1362

A Suppression Circuit for The Current Pulse During Digital Valve Drive

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As an important research direction of the hydraulic system, the digital hydraulic system has attracted wide attention. Digital valve is a typical component in digital hydraulic system. The digital valve is robust to oil contamination and has low price, and it has two states: on and off. On the one hand, in order to improve the response, the digital valve is supplied by high driving voltage to open. On the other hand, in order to reduce the current, the digital valve is powered by low driving voltage to keep open. However, the above dual voltage driving mode to improve response will lead to the current pulse, which will cause a shock to the power supply. Therefore, a current suppression circuit based on supercapacitor was proposed. A simulation model of suppression circuit was built by using MWorks simulation platform. And the circuit was verified based on the simulation model. A series of experiments were completed according to the simulation to select appropriate parameters. The results show that the suppression circuit reduce the power supply current effectively. The supply current is reduced by 71 percent at most.

Keywords: Digital Valve, Current Pulse, Suppression Circuit, Mworks.

P1385

Parameter Identification of Key Components in Mobile UPS System

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As a source of emergency power supply for the power grid, the safety and reliability of mobile UPS system has an important impact on the quality of the power supply. The normal operation of key components in the system determines the stability of the operation of the UPS system. Hence, it is of great significance to obtain the characteristic parameters of these components. This paper studies the characteristic parameter identification method for several key components in mobile UPS system based on genetic algorithm.

Keywords: UPS System, Characteristic Parameter Extraction, Genetic Algorithm.

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P1363

Full-Order State Observer Based Control for LCL-Filtered Grid-Connected Inverter with Only One Current Sensor

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For single-phase LCL-filtered grid-connected inverter, several control strategies are often used for its better performance, such as active damping for resonance suppression caused by the LCL filter, grid voltage feedforward for high quality of the output current and phase-locked loop (PLL) for grid synchronization. But these control strategies often require additional sensors, which can result in higher cost and unreliability of the whole system. At present, there are some control strategies to reduce the number of sensors, but usually two or more sensors are still needed. In this paper, a control strategy of single-sensor inverter based on full-order state observer is proposed. By sampling the inverter-side current, other state-space variables including the grid voltage and the grid current can be estimated with high accuracy. The simulation results prove that the proposed method performs well with very small observation error, and the control strategy can be easily imposed to maintain the good stability.

Keywords: Grid-Connected Inverter, Full-Order State Observer, Single Sensor, LCL Filter.

P1365

A Novel Current Injection-Based Online Estimation Method for Surface-Mounted Permanent Magnet Synchronous Machine

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This paper proposes a novel current injectionbased multiparameter estimation method for surface-mounted permanent magnet synchronous machine (SPMSM). Under constant load torque, a short pulse of $i_d > 0$ is transiently injected into the d-axis current and the variations of dq-axis inductances and rotor flux linkage have been taken into consideration.

Secondly, the stator voltage equations will be transformed to eliminate the distorted voltage that caused by voltage-source inverter (VSI) nonlinearity. Finally, in view of the volatilities of parameters, another method that can reduce the fluctuation rate of estimation results is proposed. And the effectiveness of these methods is verified through experiments on a small-power SPMSM.

Keywords: Surface-Mounted Permanent Magnet Synchronous Machine, Parameter Estimation, Adaline Neural Network, Inductance.

P1368

A Strategy for Voltage Balancing of Three-Phase Cascaded H-Bridge Rectifier

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The power electronic transfnrmer (PET) is a module-cascaded converter with high-frequency-link technnlogy to realize high-power conversion. A typical structure of PET contains a three-phase cascaded H-bridge rectifier in the first stage and several dual active full-bridge (DAB) dc-dc converters in the second stage. Due to dc-link voltage and power unbalancing in the cascaded modules in the first stage, the system may have overvoltage or overcurrent issues. In this paper, based on star-connected cascaded H-bridge (CHB), a zero-sequence voltage injection method is proposed based on the three-phase d-q model to balance dc-link voltage in mutual phase while a hybrid mndulatinn methnd is prnpnsed to realize dc-link voltage balancing in inner phase. Besides the function of the dc-link voltage balancing, the proposed method is also capable of suppressing the negative sequence and zero sequence components in the system and reducing switching losses.

Keywords: dc-link voltage balancing, star-connected cas-caded H-bridge (CHB), zero-sequence voltage injection.

P1377

Dynamic Aggregation Modeling for Droop Control Inverter Based on Slow Coherency Algorithm

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In recent years, coherency-based aggregation method has been widely used in dynamic equivalence in large-scale systems, and the dynamic response of the system can be accurately reflected by the obtained reduced-order model. Among them, the traditional slow coherency algorithm has many advantages, such as being insensitive to the location and severity of the fault and been popular in research. But it is difficult to be applied to the distributed generation network due to the model limitation and poor accuracy. To address above issues, a slow coherency and aggregation method suitable for grid-connected inverter networks based on droop control has been proposed in this paper. A slow coherency model is established and the influence of damping is analyzed based on the singular perturbation theory, and the applicability issue of droop-controlled inverter networks has been solved. In order to identify accurately the coherent power source, the fuzzy C-means spatial clustering algorithm is utilized in the modal matrix. Finally, a reduced-order model is established through the parameter aggregation method, and the simulation results verify the effectiveness of the proposed scheme.

Keywords: Slow Coherency Algorithm, Aggregation Method, Reduced Order Model, Droop Control, Dynamic Equivalence.

P1381

A Hybrid Single-Phase to Three-Phase Power Supply System With Voltage Error Compensation Strategy

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For the lack of three-phase power supply in some rural and remote regions, this paper presents a hybrid single-phase to three-phase power supply system based on reverse YNd11 transformer and phase-shifting converter with an improved control strategy. Firstly, the converter shifts the phase of the single-phase AC voltage by 60 degrees to construct the balance transformation condition of the reverse YNd11 transformer, so that the secondary side of reverse YNd11 can output symmetrical three-phase voltage. Then, this paper introduces the error caused by the non-ideal part of the control loop of the phase-shifting converter actively and reconstructs the phase-shifting converter reference voltage signal, which can be compensated without quantitative control. The output error of the phase-shifting converter is compensated, and the imbalance degree of the output voltage of the system is significantly reduced. The simulation results of the presented system with the improved control method have demonstrated the correctness and effectiveness.

Keywords: Single-Phase to Three-Phase, Rural and Remote Areas, Reverse YNd11 Transformer.

P1388

A MPPT Control Method Based on the Improved Wind-Driven Optimization

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With the development of photovoltaic power generation, there is an urgent problem to be solved about how to improve the efficiency of photovoltaic power generation systems. For the nonlinear output characteristics of photovoltaic arrays, fast and accurate tracking method of the maximum power point has become the topic of research. The traditional maximum power point tracking methods do not consider the tracking speed and accuracy at the same time, and there are often problems with oscillation and misjudgment. In order to solve the problems above, the wind-driven optimization algorithm is studied and an improved adaptive wind-driven optimization algorithm is proposed, which not only has fast tracking speed and higher tracking accuracy, but also greatly reduces the steady-state oscillation. Finally, the superiority of proposed method comparing with the wind-driven optimization algorithm has been verified with the simulation results based on MATLAB/Simulink under the sudden changes of the external environment.

Keywords: Photovoltaic Inverter, Maximum Power Point Tracking, Wind-Driven Optimization, Adaptive Algorithm.

P1395

ZVS Analysis and Control Strategy for Back-Stageof Single-Phase AC-DC-DC Converter With Low-Frequency DC-Link Voltage Ripple

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As a module of power electronic transformer (PET), single-phase isolated ac-dc-dc converter is popular in high-power applications. However, there is inherent instantaneous power difference between ac input and dc output, which leads to a significant low-frequency voltage ripple on the dc-link capacitor. It will affect the performance of dual active bridge (DAB), such as the range of zero voltage switch (ZVS) and output voltage ripple. So, the relationship between ZVS range of DAB converter and the input voltage is deduced. According to this relationship, leakage inductance of transformer is designed to realize full power range soft switching of the back-stage DAB. To suppress output voltage ripple, a feedback linearization control strategy is proposed. Finally, the rationality of the designed transformer leakage inductor and effectiveness of the proposed control strategy are verified by simulation. The simulation results show that the dc-link voltage ripple does not significantly increase the peak and RMS current of transformer, and the designed leakage inductor can realize ZVS in full power range of when the dc-link capacitor contains ripple. Moreover, the proposed control strategy can suppress the dc-link ripple transferring to the output.

Keywords: Single-Phase Isolated ac-dc-dc Converter, Low-Frequency Voltage Ripple, ZVS Range of Dab, Output Voltage Ripple Supress.

P1369

Research on Magnetic Integration Coupling Mechanism of UAV Wireless Power Transfer System

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The intelligent inspection method represented by UAV is more and more widely used in the power grid. Wireless charging technology greatly increases the endurance of UAVs which has the advantages of flexibility, safety, and high degree of intelligence. The composite compensation network represented by LCC which has constant voltage or constant current output characteristics is more widely used in wireless charging systems. However, the separate compensation inductor greatly increases the volume and weight of the coupling mechanism. Therefore, the magnetic integration technology is studied to realize the integrated design to reduce the volume and weight of the device. At the same time, the coupling mechanism is optimized to achieve the antioffset characteristics and lightweight requirements of the UAV. Finally, the system simulation results are given based on the MATLAB simulation platform.

Keywords: Wireless Power Transfer System, UAV, Magnetic Integration, Anti-offset, LCC-S.

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P1400

Power Balance Strategy of Cascaded DC Solid State Transformer Based on Virtual Impedence

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The traditional DC solid state transformer (DCSST) needs to consider the decoupling between the two control targets, and it is impossible to achieve the terminal voltage matching of a single module to achieve the efficiency optimization. In this paper, the cascaded topology can solve the above problems well, and under non-ideal conditions, the virtual impedance is introduced to suppress the system circulation and achieve the power balance of each module. Firstly, the working principle, power characteristics and control strategy of the circuit are analyzed theoretically. At the end of the paper, the simulation waveform is given to verify the effectiveness of the scheme.

Keywords: DCSST, Cascade, Power Balance, Virtual Impedance.

P1405

Optimized Design and Simulation Study of Helical Core Suitable for Non-invasive Energy Harvesting

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Online monitoring equipment is playing an increasingly important role in the electrical power networks, where its use can help reduce maintenance costs and improve grid system reliability. In this context, energy harvesting technology can help online monitoring equipment get rid of battery power supply shackles. A novel non-invasive helical core can scavenge the magnetic field energy efficiently near the current-carrying cable. In this paper, to research the optimization design method of helical magnetic core, a new method for optimizing the air gap of the helical magnetic core is proposed. A parameter K is introduced to represents the ratio between the air gap and the thickness of a single helical. When K is in the optimal range, the open-circuit voltage can be increased by 25.71%. Therefore, the proposed air gap optimization method can significantly improve the energy extraction capacity of the helical core.

Keywords: Online Monitoring, Energy Harvesting, Helical Core, Air Gap Optimization.

P1454

A Data-Driven Topology Estimation For Distribution Grid

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The topological structure of distribution grid is the basis for the realization of various functions of the future intelligent distribution grid. Aiming at the shortcomings of traditional distribution network topology estimation methods such as large amount of calculation, poor real-time performance, relying on the information provided by the AMI(advanced metering infrastructure) system, a data-driven topology estimation method in radial distribution grid is proposed. First, use the kernel density estimation method to calculate the mutual information between the voltage data of each bus to analyze the buses' connection relationship; then generate the distribution grid topology in the form of adjacency matrix according to the maximum spanning tree algorithm; The proposed method is verified through the IEEE 33-bus system..

Keywords: Data-Driven, Topology Estimation, Distribution Grid, Advanced Metering Infrastructure.

P1455

Comprehensive Benefit Evaluation of Distributed Photovoltaic Power Generation System with DC Interconnection Based on Benefit-Cost Ratio

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In recent years, the rapid development of distributed power supply and the outstanding advantages of DC distribution network lead to the project of integrating distributed photovoltaic (DPV) into DC network emerging at the right moment. Due to the related price reduction policy of PV power generation, the unmarketable price of the matched DC equipment, and the unclear impact of technical characteristics of DC grid-connection on system economy, it is necessary to establish an economical model combining the different operating modes of PV grid-connected system to evaluate the comprehensive benefit of system. Cost and benefit of PV power generation and DC distribution are considered, meanwhile the reliability and stability indicator of DC distribution are turning into power outage loss. Finally, cost and benefit of total life cycle are figured out. The result of the comprehensive benefit evaluation is characterized by the ratio, and the feasibility of the method is verified in a numerical example. Results show that the benefit of different operating modes varies greatly in the same scene. For residential low voltage DC (LVDC) power supply scene and urban intensive load area, the operating mode of unified purchasing and marketing is suitable, while industrial park are applied for self-use operating mode.

Keywords: Component, Distributed Photovoltaic, Dc Network, Comprehensive Benefit, Total Life Cycle.

P1456

Energy-Based Large-Signal Stability Analysis of DC Microgrid Considering Dynamic Interactions Between Multiple Converters

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DC Microgrid is widely investigated and developed for the flexible integration of renewable energy. However, a practical DC microgrid is easily subject to variousdisturbances, such as pulse power load, load change and grid faults. Due to the multi-loop coupling and the dynamic interactions between multiple converters, the large-signal stability of DC microgrid is difficult to be predicted. In this paper, an analytical large-signal stability (LSS) criterion is proposed for the multiple converters system of DC microgrid. Considering both source converters and load converters, dynamic models are firstly established. Based on the mixed potential function theory (MPT), the LSS criterion is developed for the system with different load models, including constant power load and dynamic power load. Furthermore, the modified LSS criterion is studied for the DC microgrid under droop control, which reveals the nonlinear correlations between stability boundaries and the load power. Eventually, extensive simulation results are presented to verify the effectiveness of the proposed stability criterion.

Keywords: DC Microgrid, Large-Signal Stability, Mixed Potential Function, Dynamic Interactions, Droop Control.

P1457

Large Signal Stability Analysis of Multi-Voltage Level DC System

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The stability region of multi-voltage level DC system is the bottleneck problem in system level stability analysis. Based on the Brayton Moser mixed potential function theory, the mixed potential function of a simple three-stage cascade system is constructed, and the unified simplified models of the system under different control modes is obtained. Then, according to the stability theorem of mixed potential function, the large signal stability criteria of the system under different control modes are proposed. Through further analysis, the key parameters affecting the large signal stability of the system are obtained to draw the large signal stability region of. Finally, the simulation results verify the feasibility of the proposed large signal stability criterion.

Keywords: Mixed Potential Founction, Large Signal Stability, Multi-Voltage Level Dc System.

P1458

Analysis for Reduced-order Model of a Typical Photovoltaic-battery Hybrid Power System

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In this paper, a small signal model of independent photovoltaic-battery hybrid power system (PBHPS) is proposed. Based on the complete small signal model of PBHPS, participation factor analysis of the system is conducted, and the state variables highly correlated with DC voltage dominant mode are identified. On this basis, keeping these highly correlated variables, the reduced-order small signal model of the system is deduced. Compared with the complete small signal model of the system, the reduced-order model equates the photovoltaic power supply to a constant power source. It can reduce the order of the state matrix and amount of computation.

Keywords: Photovoltaic-Battery Hybrid Power System (PBHPS), Participation Factor, Reduced-Order Small Signal Model, Stability Analysis.

P1459

Research on Multi-objective Optimal Scheduling of Active Distribution Network Based on Cluster Partition

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In order to solve the problem of power network coordination and management caused by the characteristics of distributed power distribution, this paper proposes a multi-objective optimal dispatching method for active distribution network based on cluster division. Firstly,

the state estimation is used to eliminate bad data and obtain more accurate system parameters. Secondly, the multi-time scale integrated optimization of active and reactive power coordination, robust correction control optimization considering the statistical uncertainty of power supply and load prediction data and linear control cost optimization based on measurement data were established to dynamically adjust the distributed power cluster to achieve optimal scheduling. The research shows that this method can quickly converge the maximum deviation of data to less than 0.003 under the severe numerical conditionsandreduce the network loss and voltage deviation to improve the economic benefit and power quality of the power grid.

Keywords: Distributed Generation, Cluster Division, Multi-Objective Optimization, State Estimation, Coordinated Control.

Session	TT28 Robotics (1)
Date	1 – 14 August 2021

P1010

Mechanical design and Optimization on a Home-based Upper Limb Rehabilitation Robot

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Robotic-assisted therapy is a well-studied method for post-stroke upper limb rehabilitation demonstrating improvements in arm function. The majority of rehabilitation robots are designed for clinical settings to which it is challenging for patients to travel to receive adequate amounts of therapy. One solution is home-based rehabilitation robots which can enable patients to engage with intensive and frequent useful therapy. Nowadays, most home-based upper limb rehabilitation robots promote planar movement, while the motion of upper limb is a three-dimensional movement in daily life. The aim of this paper is therefore, to design and optimize a conceptual design which is suitable for the home environment with three-dimensional movement promotion.

Firstly, the mechanical structure of this robot is presented; secondly, the kinematic analysis of this robot is introduced and the workspace is simulated by MATLAB; finally, the topology optimization is used to reduce the robot mass while keeping the strength and stiffness. The total estimated mass of the robot has been reduced from 14.9Kg to 12.5Kg, a reduction of 15.7% of the original design. This research presents a novel lightweight home-based upper limb rehabilitation robot with 4 degrees of freedom, which provides a suitable solution for home-based rehabilitation. This research demonstrates the potential of topology optimization combined with additive manufacturing techniques to reduce the mass of home-based rehabilitation robots a key design requirement.

Keywords: Home–Based, Upper Limb, Rehabilitation Robot, Mechanical Design, Topology Optimization.

P1064

Path Planning of Six-Axis Manipulator Based on ROS System

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In order to make the six axis manipulator smoothly cross the obstacles and reach the target position, the ROS robot operating system is used to plan the path of the robot arm. This planned model uses SolidWorks to create a six-degree-of-freedom robotic arm prototype model. Configure the robotic arm motion planning toolkit through the C++ related API interface provided by the Moveit! toolkit, then based on the RRT algorithm, plan the path of the robot arm to obtain the optimal path trajectory,and finally, it is concluded that the speed of each joint is relatively stable during the moving process of the robot arm from the initial pose to the target pose, meeting the requirements of general robot arm path error. This provides a certain theoretical reference value for the platform to control the virtual machine or realize the motion of the physical robot arm.

Keywords: ROS, Six-Axis Manipulator, RRT Algorithm, Path Planning.

P1100

Multi-Obstacle Detection Based on Monocular Vision for UAV

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Obstacle detection is the key problem of UAV autonomous obstacle avoidance. This paper proposes a multiobstacle detection method based on monocular vision. The proposed method uses YOLOv3 to detect the suspected obstacle regions. SURF algorithm is used to extract and match the feature points. The principle of visual expansion is used to confirm the obstacle. Multithreading programming technology is introduced to reduce the running time of the system. Simulation experiments are conducted to verify the effectiveness of the proposed method.

Keywords: Feature Point Extraction, Visual Expansion, YOLOv3, Multi-Obstacle Detection.

P1130

A Feasible Method for Evaluating Energy Consumption of Industrial Robots

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Establishing energy consumption models is important to achieve green manufacturing for robot automatic lines. To deal with the practical issue that the joint torque are difficult to be acquired in industrial robots, this paper aims to build dynamics model of robots from the motor torque to the robot motion. The Newton-Euler method is used to construct the model in linear in-parameter form. In addition, as the conventional excitation signals, such as sine sweep and pseudo random binary signal, are not applicable for robots with closed control architectures, this paper proposes a method to use robot built-in point-to-point motion trajectory for the system identification. In this way, the parameters in the dynamics model are identified by linear least square. Eventually, energy consumption model can be formed. Simulation and experiments are conducted on a KUKA KR60-3 robot to verify the effectiveness of the proposed method. By experiment, the accuracy of prediction of energy consumption is as high as 90.54%.

Keywords: Dynamics, Parameters Identification, Energy Consumption Model, Industrial Robots.

P1132

Design, Modeling and Control of a Novel Over-Actuated Hexacopter with Tiltable Rotors

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For traditional multi-rotor aircraft, all the rotors fixed in a same plane, the translational and rotational dynamics are coupled. This inherent feature is the reason that restricts the flexibility and agility of multi-rotors. In this paper, we propose a new idea of designing a novel rotor-tiltable hexacopter: (1) each rotor of the hexacopter can rotate around the body, (2) six arms are coupled by six bevel gears, so that tilting motion of each arm can be controlled by a servo motor. This configuration make the vehicle become an over-actuated system. Such a system realizes the decoupling control of position and attitude, and has good flexibility. Based on PID position controller and quaternion based attitude controller, we design a series of simulation experiments. The simulation results verify the tilt-hovering capability and trajectory tracking ability of the vehicle, which further proves the feasibility of this design.

Keywords: Hexacopter, Over-Actuated, Simulations, Til-thovering.

P1312

Control a Fully Actuated Aerial Vehicle under Impact of Wind Disturbance

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Mobility of a standard quadrotor unmanned aerial vehicle (UAV) is largely restricted since all of its propelling thrusts are vertical and it only possesses four degrees of freedom. As a result, traditional quadrotor UAV cannot follow the trajectory in three-dimensional space arbitrarily. The standard fixed-wing UAV performs well in high maneuvering flight. However, it cannot vertically take off, land and hover aerially. In this research, we presented a fully-actuated aircraft called Tilt Octo with inclined propellers and only internal thrust to resist external pneumatic interference. In this way, the vehicle body is capable of keeping level flight and stable hovering under windy circumstances. Notably, the unique application was logically set up in special inspection field. A controller based on the backstepping method considering external disturbance was designed and thus altitude trajectory was ensured. In particular, the anti-wind disturbance experiments have been conducted and the results demonstrated that Tilt-Octo appear superior capabilities of stationary hovering and accurate trajectory tracking.

P1326

Design of a Path-Following Controller Based on A New Tracked Vehicle Kinematics Model

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In order to improve the tracking accuracy of tracked vehicle in the process of automatic navigation. This paper combines the position and posture changes of the tracked vehicle to derive the kinematics model, and establishes the kinematics equations about the vehicle yaw rate and spatial position coordinates. According to the requirements for the convergence speed and stability of the lateral error and the rate of change of the lateral error, a steering controller combining kinematics model and state feedback system is designed. Combined with the vehicle speed and the yaw rate output by the system, the speed of the driving wheels on both sides of the track is controlled by controlling the steering angle, so as to realize the differential steering control. The simulation and experimental results show that the controller is effective and can accurately track the target path of the tracked vehicle.

Keywords: Path Tracking, Kinematic Model, Status Feedback, Differential Steering.

Session	TT29 Robotics (2)
Date	1 – 14 August 2021

P1366

Graph-based Extrinsic Calibration of Multiple 2D-Lidars

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2D-Lidars have been widely used in mobile robotics and autonomous vehicles for their precise measurement of distance. To effectively utilize the measurement of the sensor and perform data fusion, the extrinsic calibration between the equipped sensors is imperatively required. This paper presents a new method to obtain the relative pose of multiple 2D-Lidars automatically. Compared with existed researches which need human intervention by using artificial calibration target or synchronized sensors, our method is designed for the fully automatic calibration. Moreover, the method can also be further promoted to apply to other sensor systems. When the mobile robot is placed in the environment and automatically traverses the environment with arbitrary trajectory, the measurement data collected by 2D-Lidars at different moments and the motion estimation information are incorporated to construct the factor graph. Then a robust optimization is achieved to acquire the optimum solution. The performance of our method is validated by simulation and real-world experiment.

P1409

A Review of Compliant Control for Collaborative Robots

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Collaborative robots that can directly interact with humans have become a new trend in the robotics field. To achieve safe and friendly human-robot interaction, the compliant control of collaborative robots is extremely important, especially the compliant control of each joint. Also, the number of publications has increased yearly. In this article, we summarize the compliant control methods that have been proposed and applied in the robot system and classify compliant control methods into three categories: force-based which needs to know the joint torque/force and limited by the performance of force controller; model-based which can achieve high control accuracy but limited by the model accurate; external force-based which can increase the transparency but needs to know the external force. Then we propose possible future research directions.

Keywords: Collaborative Robot, Human-robot Interaction, Compliant Control, Joint Control, Impedance Control.

P1417

Using UHF-RFID Signals for Robot Localization Inside Pipelines

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Underground water pipes are important to any country's infrastructure. Overtime, the metallic pipes are prone to corrosion, which can lead to water leakage and pipe bursts. In order to prolong the service life of those assets, water utilities in Australia apply protective pipe linings. Long-term monitoring and timely intervention are crucial for maintaining those lining assets. However, the water utilities do not possess the comprehensive technology to achieve it. The main reasons for lacking such technology are the unavailability of sensorsand accurate robot localization technologies. Feature based localization methods such as SLAM has limited use as the application of liners alters the features and the environment. Encoder based localization is not accurate enough to observe the evolution of defects over a long period of time requiring unique defect correspondence.

This motivates us to explore accurate contact-less and wireless based localization methods. We propose a cost-effective localization method using UHF-RFID signals for robot localization inside pipelines based on Gaussian process combined particle filter. Experiments carried out in field extracted pipe samples from the Sydney water pipe network show that using the RSSI and Phase data together in the measurement model with particle filter algorithm improves the localization accuracy up to 15 centimeters precision.

Keywords: Infrastructure Robotics, Linings, Localization, Particle Filter, Pipes, Robotics for Smart Cities, RFID, Roboticinspections, UHF-RFID.

P1453

A Review of Powered Backdrivability of Robot Actuators for Human-Robot Interaction

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To achieve effective and safe Human-Robot Inter-action (HRI), much attention is paid on the backdrivability of robot actuators. According to the realization approaches, the backdrivability of actuators are classified into two categories, i.e., powered and unpowered backdrivabilities. This paper focuses on the powered backdrivability realized through controlling actuator reversely based on the sensor feedback. A thorough literature review is conducted to obtain an in-depth understanding about the research advances on powered backdrivability of actuators. The definition, classification and evaluation methods of the actuator backdrivability are discussed firstly. Powered backdrivabilities with force sensors and encoders are reviewed. The research direction of powered backdrivabilities is proposed based on the discussion.

Keywords: Human-Robot Interaction, Robot Actuator, Pow-Ered Backdrivability.

Session	TT30 Signal and Information Processing (1)
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P1003

User Emotion Recognition Method Based on Facial Expression and Speech Signal Fusion

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In human-computer interaction, it is an urgent problem to use facial expressions and speech information to identify the user's continuous emotions, and the key factors affecting the recognition accuracy are the data deficiencies during the fusion of speech and facial information, and the abnormal frames in the video. In order to solve these problems, a user emotion recognition system based on the fusion of facial expressions and speech multimodality is designed. In the part of facial expressions, Gabor transform continuous emotion recognition method based on data increments is proposed. In the part of speech information, Mel-scale Frequency Cepstral Coefficients (MFCC) is used to extract speech features, and user emotions are recognize through transfer learning. Finally, in the late fusion, multiple linear regression is used for multi-modality to verify the method in this paper. This paper uses the AVEC2013 dataset with Arousal-Valence label to conduct a valid experiment on the proposed method. The experimental results prove that the method improves the accuracy of user emotion recognition.

Keywords: Emotion Recognition, Gabor Transform, TransferLearning, Multimodal Fusion, Arousal-Valence.

P1081

Homology Feature Extraction Method of Malware Based on Genetic Algorithm and Association Mining

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The behavior characteristics and programming structures of malware are usually analyzed on the basis of its disassembly file. The basic instruction sequence of malicious disassembly file describes the purpose of program design and the programming habits of the writers. In order to mine the family behavior characteristics of malware, the simplified sequences of assembly instruction opcode field are constructed.

It is pointed out that for the simplified code population formed by unequal length binary byte code sequence, the maximum frequent sequence set represents the family malicious behavior pattern. To accelerate the process of malicious pattern extraction and obtain the homologous characteristics of code family, a genetic frequent sequence discovery algorithm named AMFIS is designed for simplified code population. This algorithm combines the technical advantages of swarm intelligence optimization and association mining idea. The process of association analysis can solve the feature fitting of malicious models, and the process of genetic evolution can solve the incremental prediction of abnormal patterns. The AMFIS has been applied to the kaggle sampling data set, and the pattern matching results of the frequent sequence set verify that this algorithm has high credibility for the analysis of malicious family behavior.

Keywords: Malicious Code, Feature Extraction, Genetic Algorithm, Association Mining.

P1086

Modified Binary Ant Colony Optimization for Drift Compensation

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In data analytics and pattern recognition, feature selection is a critical task to provide a subset of features with minimum redundancy. This reduces the computation time as well as cost. In this manuscript, a correlation based feature selection approach based on a modified binary ant colony optimization algorithm (MBACO) is proposed. Combined with random forest regression, the proposed MBACO algorithm is customized for a drift compensation application. In this application, the ant road map is initialized to avoid the local optimum. The proposed method is compared with that of binary particle swarm optimization on a well-known UCI dataset. Experimental results show that the proposed method exhibits better performance over the binary particle swarm optimization based approach.

Keywords: Ant Colony Optimization, Random Forest Regression, Drift Compensation.

P1123

Low-altitude UAV Recognition and Classification Algorithm Based on Machine Learning

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Aiming at the difficulty of target location and classification in low altitude surveillance and anti Unmanned Aerial Vehicle(UAV) system. This paper mainly studies the recognition algorithm of low-altitude UAV. First, the UAV image is preprocessed, and candidate partial images of different sizes and positions are generated through a sliding window, and the moment invariant features of the image are extracted. Then, the neural network is used to train the image, and the support vector machine classifier is used to classify the aircraft, and then the recognition and classification algorithm of the aircraft target in the low-altitude airspace are finished. Based on the theoretical algorithm research, this paper uses MATLAB software to simulate and analyze the aircraft recognition algorithm, and the accuracy is more than 90%. The results show that the research algorithm can be used for UAV recognition and low-altitude aircraft classification.

Keywords: Low-altitude Airspace, Unmanned Aerial Vehicle(UAV), Image Processing, Neural Network, Support Vector Machine(SVM).

P1166

Simulation of Intelligent Airborne Sensor for Interting System with Compensation of Temperature And Presssure

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The accident of fuel tank explosion is an important factor affecting aircraft performance and reliability. Therefore, the inerting system of aircraft fuel tank has been developed in the past decades. The purpose is to reduce the oxygen concentration by filling the tank with nitrogen.

In order to monitor the oxygen concentration in the tank, we use tunable diode laser absorption spectroscopy (TDLAS) to measure. Based on the commonly used Matlab numerical simulation module Simulink, this paper establishes the simulation model of intelligent oxygen concentration sensor, and carries out the simulation experiment of measuring oxygen concentration. We compare the influence of different temperature and pressure on the measurement results, and prove the necessity of temperature and pressure compensation. The experimental results show that TDLAS can obtain higher accuracy by adopting the second harmonic detection method under noisy conditions and can adapt to the high temperature and high pressure environment of the fuel tank. In addition, the research results can provide a theoretical basis for the development of TDLAS based aircraft equipment.

Keywords: Inerting System, Oxygen Concentration Sensor, TDLAS.

P1340

Off-Grid DOA Estimation of Coherent Signals Using Weighted Sparse Bayesian Inference

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In this paper, a high-precision direction-ofarrival (DOA) estimation of coherent signals algorithm using the improved off-grid sparse Bayesian inference is proposed. Firstly, we construct a weighted vector via IMUSIC algorithm to provide a priori information of spatial distribution, which can improve the estimation accuracy and efficiency. Then, to further reduce the approximate error of the first-order offgrid model, the steering vector is reformulated by the secondorder Taylor expansion. Finally, the steering vector higherorder approximation model and weighted sparse Bayesian inference are combined together to realize the estimation of DOA. Extensive simulation results demonstrate the superior performance of the proposed algorithm under the conditions of coherent signals and low SNR.

Keywords: Direction-of-arrival (DOA), Off-Grid Model, Sparse Bayesian Inference, Coherent Signals.

P1341

Improved Extreme Learning Machine Method for Wind Turbine Clutter Mitigation

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Due to its rapid learning capacity and well generalization performance, the Extreme Learning Machine (ELM) is creatively introduced into wind turbine clutter (WTC) mitigation for weather radar. Aiming at the difficulty of setting the number of hidden layer nodes in ELM algorithm, an improved algorithm–Incremental Extreme Learning Machine (I-ELM) is proposed. First, the training samples are constructed by using the radial velocity and spectral width of the weather signal from the neighboring range bins. Then through the training of samples, the model parameters are searched and optimized according to the least square criterion. Finally, the optimized I-ELM model is utilized to recover the weather signal of the contaminated range bin. Theoretical analysis and simulation results show that the proposed algorithm can effectively suppress WTC and significantly reduce the deviation of radial velocity estimation and spectral width estimation caused by WTC contamination.

Keywords: Weather Radar, WTC, ELM, I-ELM.

Session	TT31 Signal and Information Processing (2)
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P1024

Digital Filter Algorithm based on Complex Weight and Pixel Matching in AWGN Environment

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Influenced by the Fourth Industrial Revolution, modern society uses various communication devices. Accordingly, much attention has been paid to noise reduction in the data transfer process. This paper proposes a filtering algorithm to remove the additive white Gaussian noise (AWGN) that occurs in the digital image transmission process. The proposed algorithm removes the noise based on pixel matching and composite weight. Pixel matching compares the input pixel value and surrounding pixel pattern to find a pixel with a similar pattern, which is then used in the estimate calculation. The composite weight is intensified according to the difference in the pixel's spatial distance and pixel value to compensate for the loss that occurred in the noise removal process. To evaluate the proposed algorithm, simulations were conducted with existing AWGN removal algorithms and the proposed algorithm was analyzed by comparing peak signal-to-noise ratio and expanded image.

Keywords: Image Processing, Pixel Matching, Complex Weight, AWGN.

P1033

A Continuous Charge Estimation for Gravitational Wave Detections

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Charge Management System is one of the most important components for space gravitational measurement. Gravitational wave detector is only available when the charge on Test Mass is less than a certain level about $10^{-13}C$. The current method for charge management will actively put a stimulated electrical field on the Test Mass to estimate its charge level which will interrupt the gravitational detection. This paper presents a non-disturbed method for the charge estimation through observing the normal movement of Test Mass. The principle and mathematic equation are introduced, and the validation is performed by using the dynamic simulation. The simulation results show that the estimation accuracy can reach the magnitude of $10^{-18}C$, which shows a significant potential for the actual applications.

P1126

Design and Realization of Broadband and High Precision IEPE Accelerometer Signal Conditioner

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Broadband micro-vibration measurement for aerospace, vehicle, industrial inspection and earthquake prediction is urgently required, therefore a broadband and high precision IEPE accelerometer signal conditioner is designed in this paper. The Integral Electronics Piezoelectric(IEPE) accelerometer signal conditioner includes constant current source circuit, filter circuit, voltage follower circuit, single-ended to differential circuit and amplifier circuit. The IEPE accelerometer signal conditioner circuit board is printed. Then, the open-loop calibration experiment and closed-loop contrast experiment are carried out on the developed IEPE accelerometer signal conditioner circuit board. The open-loop calibration experimental results show that the phase difference of output signal is less than 2°, when input standard sinusoidal signal of 0.2Hz-1KHz to the developed IEPE accelerometer signal conditioner. The closed-loop contrast experimental results show that the root mean square(RMS) of error of the developed IEPE accelerometer signal conditioner and the same type signal conditioner of PCB company are about 0.0504mg. The developed IEPE accelerometer signal conditioner has broad application prospects in the field of broadband micro-vibration engineering.

Keywords: IEPE, Accelerometer, Filter, Amplifier, Broadband, Precision, Micro-Vibration.

P1157

A Bilateral Texture Filtering Based Cloud Detection Method for VHR Satellite Images

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New commercial satellites in orbit such as GeoEye-1, WorldView-3, and PlanetLabs can provide and update very high resolution (VHR) images of the Earth surface frequently. Such VHR satellite images contain a lot of fine spatial details and texture information, which pose challenges to existing cloud detection techniques. To avoid high demand for computing resource and over dependence on spectra, a bilateral texture filtering based cloud detection method is proposed in this paper. Firstly, the proposed method builds a significance map to divide the input image into noncloud regions and candidate cloud regions. Secondly, an optimal thresholding is calculated and used on the significance map to get a coarse result of detection. Then, the multiscale BTF is employed to capture the accurate detail map of the input image to remove the noncloud regions in the coarse result of detection. The final binary result is obtained by erode, dilate and guided feathering processes. The experiment is carried out on two sets of VHR satellite images.

Subjective analysis and objective evaluations show that the proposed method works well for RGB color and grayscale images. It can produce high accuracy cloud detection results and outperforms some existing traditional methods.

Keywords: Satellite Image, Cloud Detection, Bilateral Texture Filter, Accuracy, Very High Resolution.

P1169

Censored Regression System Identification based on the Least Mean M-estimate Algorithm

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Classical adaptive algorithms have good convergence performance in linear regression system identification. However, they will face performance degradation while dealing with censored data since only incomplete information can be obtained. In this paper, the least mean Mestimate algorithm for censored regression (CR-LMM) is proposed for the robust parameter estimation. To compensate for the bias caused by censored observation, the probit regression model is employed to derive the estimated error for constructing the M-estimate cost function. The cost function can expel the adverse impact of the impulsive noise, and it is solved by the unconstrained optimization method. Computer simulations in the impulsive environment are carried out to demonstrate that the proposed CR-LMM algorithm exhibits better convergence performance than the existing algorithms in censored regression system identification scenarios.

Keywords: M-estimate, Adaptive Filters, Censored Regression, Parameter Estimation, Robustness

P1173

Multimodal Sensor Selection for Multiple Spatial Field Reconstruction

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The paper addresses the multimodal sensor selection problem where selected colocated sensor nodes are employed to effectively monitor and efficiently predict multiple spatial random fields. It is first proposed to exploit multivariate Gaussian processes (MGP) to model multiple spatial phenomena jointly. By the use of the Matern cross-covariance function, crosscovariance matrices in the MGP model are sufficiently positive semi-definite, concomitantly providing efficient prediction of all multivariate processes at unmeasured locations. The multimodal sensor selection problem is then formulated and solved by an approximate algorithm with an aim to select the most informative sensor nodes so that prediction uncertainties at all the fields are minimized. The proposed approach was validated in the real-life experiments with promising results.

Keywords: Multimodal Sensing, Sensor Selection, Multivariate, Multiple Spatial Fields, Multivariate Gaussian Process, Multivariable.

P1175

Multivariate versus Univariate Sensor Selection for Spatial Field Estimation

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The paper discusses the sensor selection problem in estimating spatial fields. It is demonstrated that selecting a subset of sensors depends on modelling spatial processes. It is first proposed to exploit Gaussian process (GP) to model a univariate spatial field and multivariate GP (MGP) to jointly represent multivariate spatial phenomena. A Matérn crosscovariance function is employed in the MGP model to guarantee its cross-covariance matrices to be positive semi-definite. We then consider two corresponding *univariate* and *multivariate sensor selection* problems in effectively monitoring multiple spatial random fields. The sensor selection approaches were implemented in the real-world experiments and their performances were compared. Difference of results obtained by the univariate and multivariate sensor selection techniques is insignificant; that is, either of the methods can be efficiently used in practice.

Keywords: Sensor Selection, Multivariate, Univariate, Spatial Fields, Gaussian Process, Multimodal Sensing, Multivariable.

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P1179

Diffusion Affine Projection M-Estimate Algorithm for Multitask Networks

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The estimation performance of multitask diffusion affine projection algorithm (MD-APA) will be affected in impulsive noise environment. To overcome this shortcoming, in this paper, a multitask diffusion affine projection M-estimate (MD-APM) algorithm is derived by using the M-estimate function in the multitask network. Simulation results demonstrate that the proposed MD-APM algorithm shows good estimation performance than MD-APA and MD-APSA under impulsive interference environment.

Keywords: Affine Projection Algorithm, Multitask Network, M-Estimate, Impulsive Noise.

P1185

Robust Diffusion Recursive Least M-Estimate Algorithm Against Impulsive Noise

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In this paper, a novel robust diffusion algorithm called diffusion recursive least M-estimate (DRLM) is proposed to enhance the robustness of the DRLS algorithm in impulsive noise environments, which is derived by replacing the square error term of the cost function of the diffusion recursive least square (DRLS) algorithm with the M-estimate function. Simulation results demonstrate that the proposed DRLM algorithm performs well than other existing diffusion algorithms for the distributed parameter estimation in impulsive noise environments.

Keywords: Diffusion Cooperation, Recursive Least Square, M-estimate, Impulsive Noise

P1186

Bias-Compensated Subband Adaptive Filter Algorithm Based on Maximum Correntropy Criterion

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This paper proposes a bias-compensated subband adaptive filter algorithm based on maximum correntropy criterion (BC-MCC-SAF), which combines the biascompensated method into the maximum correntropy criterion normalized subband adaptive filter (MCC-SAF) algorithm. Although the conventional MCC-SAF algorithm has achieved robustness against impulsive noise, it generates biased estimation when the system input is noisy. By incorporating bias-compensated term into MCC-SAF, the bias caused by the input noise can be effectively eliminated. Simulation results demonstrate that the proposed algorithm not only obtains robust performance in the impulsive noise environment but also achieves improved performance under noisy input.

Keywords: Normalized Subband Adaptive Filter, Bias-compensated, Maximum Correntropy Criterion, Noisy Input, Impulsive Noise.

P1188

Robust Filtering of Affine-Projection-Like Maximum Correntropy Algorithm with Bias-Compensated

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In this paper, a robust adaptive filtering algorithm of the affine-projection-like maximum correntropy based on the bias compensation (BC) is proposed. The proposed bias-compensated affine-projection-like maximum correntropy (BCAPLMC) algorithm is derived by using the cost function based on the maximum correntropy criterion (MCC) and the BC method, which can effectively reduce the adverse effects of impulse noise and input noise on the filter weight updating. Besides, the weight updating formula of the BC-APLMC algorithm is derived. Finally, the simulation results show that the BC-APLMC algorithm is robust in the presence of input noise and impulse noise.

Keywords: Affine-Projection-Like, Maximum Correntropy Criterion, Bias-Compensated, Impulsive Noise, Noisy Input.

P1190

Hyperbolic Secant Function Algorithms for Nonlinear Active Noise Control models of Kernel Mapping Types

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In the case of nonlinear characteristics of noise signals and control systems, the control effect of linear active noise control(ANC) algorithms will be degraded. The kernel adaptive filters (KAFs) can better solve the nonlinear problem by mapping the filtered reference signal to the high dimensional reproductive kernel Hilbert feature space (RKHFS). However, the operations of kernel function require incremental costs with mass input data. To solve this problems, the random Fourier filters (RFFs) achieves nonlinear approximation by mapping the filtered reference signal to the random Fourier feature space (RFFS). This article briefly reviews these two models, and proposes the K-FxHSF and RFF-FxHSF algorithms for impulsive noise environment. Simulation experiments show that the proposed algorithm can achieve ideal performance in the case of nonlinear noise paths.

Keywords: Active Noise Control, Kernel Adaptive Filter, Random Fourier Filter, Hyperbolic Secant Function.

P1203

An Improved Unsupervised Color Correction Algorithm for Underwater Image

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Aiming at the problems of low contrast, dim, noise interference and color distortion caused by the attenuation and scattering of light in underwater propagation, an improved unsupervised color correction algorithm is proposed. Firstly, according to the attenuation characteristics of light R, G and B in underwater environment, color components of R, G and B are balanced and contrast enhanced; secondly, the image is mapped into HSV color model space, and the contrast of S and V components are stretched; and finally, the details and contours of the underwater images are enhanced by a method of limiting contrast adaptive histogram equalization.

Experiments are carried out on the underwater image enhancement reference data set (UIEBD), the results show that the proposed algorithm can correct the underwater image color in different complex environments well. And contrast, saturation and image details of the enhanced underwater image are all improved, and the algorithm is evaluated by MSE, PSNR, SSIM UQI and VIF. Compared with deep learning based algorithm (DUIENet), the average value of indexes MSE with the proposed algorithm is decreased by 4.32%, SSIM and VIF are increased by 1.12% and 26.79%, respectively; compared with traditional algorithms, the total average value of indexes MSE with the proposed algorithm is decreased by 62.9%, PSNR, SSIM, VIF and UQI with the proposed algorithm are increased by 16.6%, 8.43%, 14.52% and 16.88%, respectively.

Keywords: Underwater Image Enhancement, Color Model, Contrast Stretching, Quality Assessment.

P1274

Augmented Complex Least Mean Square/Fourth Algorithm for Adaptive Frequency Estimation

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In order to solve frequency estimation of three-phase unbalanced power system, we propose an augmented complex least mean square/fourth (ACLMS/F) algorithm. The least mean square/fourth (LMS/F) algorithm combines advantages of least mean square (LMS) algorithm and least mean fourth (LMF) algorithm, which has superior performance in noisy environments. The Clarke's transformation was used to get the information of three-phase voltage signal simultaneously, so the proposed algorithm will have better robustness. To improve the performance in unbalanced power systems, the widely linear modelling is introduced into the traditional complex-valued adaptive algorithm. The performance of ACLMS/F is texted in some situations usually appearing in the power system.

Keywords: Augmented Complex Least Mean Square/Fourth (ACLMS/F), Frequency Estimation, Widely Linear Modelling, Unbalanced Three-Phase Voltage.

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P1372

Supraharmonics Transfer Characteristics of Transformer

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Supraharmonic source such as electric vehicles and new energy power generation devices are connected to the grid through transformers, which lead to an increasing supraharmonics content in the system. At present, there are few studies on the transfer characteristics of transformers under background of gird supraharmonics. The influence of the internal physical properties of transformer on transfer characteristics are needed to be further studied. In this paper, based on the high frequency model of transformer with distributed capacitance, the voltage gain and current gain functions are derived. Furthermore, the influences of distributed capacitances and leakage inductance on transfer transformation characteristic is revealed, which has significant reference to solve the problem of supraharmonics in power system.

Keywords: Supraharmonics, Transfer Characteristics, Voltage Gain, Distributed Capacitance.

P1373

The Tikhonov Regularization Method Improved by Genetic Algorithm is used to Retrieve the Non-Spherical Particle Spectral Distribution

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In this paper, an improved Tikhonov regularization method based on genetic algorithm is proposed to retrieve the non-spherical aerosol particle spectral distribution. Based on the ellipsoid and the cylindrical shape aerosol particles, for example, the T matrix method is used to get the ball, aerosol optical parameters using genetic algorithm combining with Tikhonv regularization method, fitting the same refractive index under the environment of different forms of spherical particle distribution, after analyzed the optical parametric data for the influence of particle distribution in inversion algorithm. The experiments show that the Tikhonov regularization method based on the improved genetic algorithm proposed in this paper is an effective method to retrieve the non-spherical aerosol particle spectral distribution, and the inversion effect is better.

Keywords: Non-Spherical,T-Matrix, Genetic Algorithm, Size Distribution.

P1413

Short Term Estimation of Environmental Variables for Improving The Fault Tolerance of Distributed Control Networks

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Methodologies for estimating missing sensor data in order to assure proper functionality of a monitoring and control system are presented. Short term forecasting models for learning the dependencies between the measured sensor values are analyzed. Experiments were performed in Matlab for selecting a model and its associated structure appropriate for deployment on an embedded module. Once the structure is fixed, the embedded module is then responsible for estimating the model parameters and forecasting the environmental variables for a short time horizon.

Keywords: Fault Tolerance, Short-Term Estimation, Distributed Control, Embedded Systems.

P1414

Non-Contact Vital Signs Detection Using mm-Wave Radar During Random Body Movements

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Vital signs such as heartbeat and respiration signals are significant indicators for health care and clinical applications. Non-contact vital signs detection via mm-wave radar has attracted more attention due to more comfortable experience and lower burden. However, the non-contact heartbeat and respiration signals detection with random body movements is more challenging. In this paper, we propose a general framework to address this problem. It is termed DRSEPK and consists of signal decomposition and reconstru-ction, spectrum estimation and spectral peak tracking. Signal decomposition and reconstruction is applied for denoising and reconstructing cleaned signal. Spectrum estimation aims to get high-resolution frequency spectrum. The spectral peak tracking can select correct spectral peaks corresponding to breath rate (BR) and heartbeat rate (HR). Experiments are conducted using frequency modulated continuous wave (FMCW) radar on ten subjects who are typing on a laptop. The results show that the DRSEPK framework has high estimation accuracy and is reliable for non-contact vital signs detection during random body movements

Keywords: Heartbeat Detection, Respiration Detection, Random Body Movement, Mm-Wave Radar, DRSEPK Framework.

P1460

Machine Vision Based Autonomous Loading Perception for Super-huge Mining Excavator

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The super-huge mining excavator has agiant structure of work devices and harsh working conditions, which results in a limited view of the operator. Therefore, howto assistthe operator indetermining the relative position of the bucket and the dump truck during the excavator loading operations has become a prominent issue. To solve this problem, this paper proposes a relative position perception and correction schemebased on machine vision technology. First, the Scale Invariant Feature Transform (SIFT) is used to recognize the dump truck target in the image captured by the camera. Then, the positioning algorithm based on color detection is used to identify and analyze the markers on thedump truck. Finally, through simulation tests, the proposed scheme can accurately judge the relative position of the bucket and the dump truck, and give the excavator a suitable rotation signal. Theresearch is of great significance to the development of unmanned and intelligent excavators

Keywords: Super-Huge Excavator, Autonomous Loading Perception, Machine Vision, Position Detection.

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P1358

Research on Influencing Factors of Voltage Control for MMC type Mobile DC Ice Melting Device

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The mobile DC ice melting device based on full bridge MMC has the advantages of modularization, strong scalability, high redundancy and wide range of DC voltage generation, which is suitable for solving practical engineering problems such as line icing. In addition to deicing, this kind of device can move flexibly and has the potential of voltage support similar to STATCOM. It is also suitable for solving voltage sag caused by fault or load change. This paper first analyzes the working principle of MMC in the mobile ice melting device, and then puts forward the specific control strategy when the device is used as STATCOM; then studies the influencing factors of MMC mobile DC ice melting device voltage governance; finally establishes a simulation model for verification. When the short-circuit capacity of the configuration point of MMC mobile DC deicing device is determined, the reactive power required by the support voltage is only linearly related to the sag amplitude; when the sag amplitude is fixed, the reactive power required by the support voltage is only related to the short-circuit capacity of the configuration point; the voltage governance is less affected by the load capacity.

Keywords: Modular Multilevel Converter, Mobile Dc Deicing Device, Control Strategy, Voltage Management, Power Quality.

P1359

SVG Control Function and Realization of Modular Multi-Level DC Ice Melting Device

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In recent years, transmission line icing caused by ice and snow disasters threatens the safe and stable operation of power system. Among the existing ice melting devices, the modular multilevel DC ice melting device has the characteristics of less harmonic content, small volume, simple switching mode, low failure rate and small power capacity, which has significant advantages in economy and technical feasibility. However, because the modular multilevel DC ice melting device is only used during the freezing period in winter, the problem of low utilization rate of the device is also prominent. In order to solve the problems of large volume, high harmonic content, high cost and low utilization rate in the operation of traditional DC ice melting device, this paper proposes a control function and implementation method of modular multilevel DC ice melting device based on SVG. During non-ice melting period, the control strategy can output or absorb reactive power according to the needs of the system to support the grid voltage and improve the utilization rate of equipment. This paper first analyzes the topology and working principle of the modular multilevel DC deicing device, then introduces the carrier phase shift modulation strategy of the modular multilevel DC deicing device, and puts forward the SVG control strategy of the modular multilevel DC deicing device under three-phase balanced and unbalanced conditions, so as to realize load dynamic reactive power compensation and grid voltage drop suppression,

The reliability of the system is improved significantly. Finally, based on the above method, the Simulink simulation model is established to verify the effectiveness of the control strategy, and the simulation waveform is given for analysis.

Keywords: DC Ice Melting, Reactive Power Compensation, MMC , SVG.

Session	SS02 Application of data science and technology in the Energy Internet
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P1013

Graph Matrix Completion for Power Product Recommendation

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The recommendation system has achieved great success for decades, some are still not solved well, especially in data sparseness. Graph convolution network(GCN) can be well applied to recommender systems, but the previous methods only consider vector representations of users and items. The latent in user-item interactions is not encoded in the embedding process. As such, the resultant embeddings may not be sufficient to capture the collaborative filtering effect. we propose a new Graph matrix completion(GMC) framework, which add user-item interaction information and side information to the graph auto encoder network, and capture differentiable information transmission on bipartite interaction graph. Multi-layer decoder is adopted to optimize loss for better map the potential representation of user/item. Our model is evaluated on multiple benchmark datasets and outperforms the state-of-the-art algorithm.

Keywords: Component, Graph Matrix Completion, GAE, Multi-Layer Decoder.

P1278

A Data Processing Method for Mountain Photovoltaic Power Plants Based on Time and Space Characteristics

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The complex environment of mountain photovoltaic (PV) power plant brings great challenges to the operation and maintenance of the power plant. In order to better realize the intelligent operation and maintenance of mountain PV power plant, and we propose a method to analyze and aggregate the output curve of mountain PV power plant according to the temporal and spatial correlation. This data pre-method analyzed the correlation and difference between the series current data of the mountain PV power plant at different dates and locations. The data was reconstructed by multiple fitting and *K*-means clustering, and the typical day was filtered and the azimuth and inclination were divided. It can effectively solve the problem of inaccurate fault diagnosis caused by dirty actual output data of mountain PV power plants.

Keywords: Mountain PV Power Plant, Current Curve, Typical Day, Azimuth, Inclination.

P1335

Research on the Fault-Diagnosing Method in the Operation of the Threshing Cylinder of the Combine Harvester

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Combine harvester is operated in the complex and changeable working environment, with heavy load and long working time. During the working process of the combine harvester, many problems including too fast the operation speed and the uneven feeding amount could cause

blockage of the threshing cylinder, affecting the working efficiency, and causing great damage to the combine harvester. Blockage of the threshing cylinder can be found out through observing rotate speed and torque. Previous fault diagnosis methods only diagnosed the rotate speed without considering impacts from other parameters. These methods easily underreport faults and have limited diagnostic capabilities. In this paper, a multiparameter trend-change fusion analysis method based on the instantaneous change trend of the target signal was proposed to comprehensively analyze the rotate speed and torque. The rules of early warning and alarming of the jam fault were also defined: an alarm is issued when the rotate speed is less than 40% the upper limit and the torque is greater than 70%, and a warning prompt is given when the fault judgment value I>0.01. With the corn combine harvester as the analysis object, experiments show that the proposed fault-diagnosing method can effectively distinguish the real jam and false jam in the early warning, and give the early warning prompt and alarm in time without false alarm or underreport. The proposed method can help to reduce the number of stoppages during the operation caused by false alarm and the damage caused by underreport. It can improve the operation efficiency and save maintenance costs.

Keywords: Fault diagnosis, Fusion analysis, Combine harvester, Threshing Cylinder.

P1396

A Fast Modeling Method using Limited Resources for 3D Campus

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In the modern era, the demand of 3D campus model is increasing. In this paper, a fast modeling method developed by using limited resources for 3D campus. The study combined 3D modeling technology with Unity3D platform, using limited resources, such as maps on the web and photos taken by students without the field measurement data. On the basis of this research, the campus model can be created quickly and conveniently, and this method is also very suitable for 3D modeling of an urban area.

Moreover, the study realized a campus roaming and basic interactive functions. This research is based on Unity3D platform.

Keywords: Virtual 3D Model, Unity3D, Virtual visualization Procedural Modeling.

P1163

An Adaptive Power Grid Friendly Response Strategy for Commercial Buildings Based on Power Cyber-physical System

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In new energy high permeability power grid, the uncertainty of new energy brings great challenges to the security and stability of the power grid. This paper proposes an adaptive grid-friendly response strategy for commercial buildings based on power cyber-physical system (CPS). Firstly, the overall framework of CPS of commercial buildings with the functions of each layer is established. Then, the procedure and model of the asynchronous cooperative adaptive grid friendly response strategy is constructed. Finally, the simulation results show that the proposed method is effective and reasonable in IEEE-14 case with commercial buildings' friendly response to the power grid. This paper provides a reference for the application of power grid friendly technology, realizes the optimal allocation of resources, and increases the safety and stability of power grid.

Keywords: Commercial Buildings, Cyber-Physical System, Demand Response, Grid Friendly.

P1171

Ensemble Empirical mode Decomposition Based Electrical Power Demand Forecasting for Industrial User

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Aiming to control the industrial power demand characterized by strong fluctuation and impact, this paper studies the multi-step forecasting problem of ultra-short term demand load. Based on the integrated empirical mode decomposition method, the signals with different frequencies are effectively separated by decomposition. Then, the long short memory neural network is used to independently predict different signal subsequences, and finally the subsequence prediction results are combined. The experimental results show that the proposed method can well predict the industrial demand load, and the indices of prediction accuracy, such as MAPE, MAE, and NRMSE, are all controlled within 2%, and are significantly better than several classical time series prediction model, as well as the latest literature algorithms. The transfer error is also eliminated in the method, which represents good prediction accuracy and stability to meet the demand of demand control.

Keywords: Power Load Forecasting, Electric Power Demand, Empirical Mode Decomposition, EEMD, LSTM.

P1352

An Explainable Recurrent Neural Network for Solar Irradiance Forecasting

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The factors affecting solar irradiance are usually complex and diverse, making it difficult to accurately predict the photovoltaic power generation. In this paper, an explainable recurrent neural network (ExRNN) algorithm is proposed based on deep recurrent neural network (RNN) and additive index model for solar irradiance forecasting problems. The proposed ExRNN is designed as an ante-hoc explainable algorithm with cyclic units by linearly combining single-feature models to learn explainable features of solar irradiances, and the ridge function is used as an activation function to extract and explain mapping correlations between meteorological features and solar irradiances. Furthermore, the RNN is used with memory characteristics to discover the time correlation hidden in the solar irradiance data sequence and retain the explainability. Therefore, the factors affecting solar irradiances can be quantified by the proposed ExRNN, and a legible explanation on the relationship between meteorological inputs and solar irradiances can be provided. Solar irradiance samples from Lyon France are used to evaluate the prediction accuracy and explainability of the proposed ExRNN.

Keywords: Deep Learning, Explainability, Solar Irradiance Forecasting, Recurrent Neural Network, Renewable Energy.

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P1111

Energy-Efficient NOMA with QoS-Guaranteed Power Allocation for Multi-User VLC

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In this paper, we propose an energy-efficient nonorthogonal multiple access (NOMA) technique for multi-user visible light communication (VLC) systems, by adopting a lowcomplexity quality of service (QoS)-guaranteed power allocation strategy. From the perspective of energy saving, we design the energy-efficient NOMA-enabled multi-user VLC system with the goal to achieve maximal energy efficiency (EE). The closed-form QoS-guaranteed optimal power allocation strategy is obtained and the analytical EE of the proposed NOMA-enabled multiuser VLC system is derived. The analytical and simulation results show that, for a VLC system with ten users, the average EE can be improved by 19% when adopting the proposed NOMA in comparison to NOMA with gain ratio power allocation (GRPA), and the EE improvement becomes much more significant when the users have more diverse QoS requirements.

Keywords: Visible light communication (VLC), multi-user, non-orthogonal multiple access (NOMA), power allocation.

P1112

OFDM-Based Generalized Spatial Modulation for Optical Wireless Communication

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In this paper, we propose two orthogonal frequency division multiplexing (OFDM)-based generalized spatial modulation (GSM) techniques, i.e., frequency domain GSM (FDGSM) and time domain GSM (TD-GSM), for indoor multipleinput multiple-output optical wireless communication (MIMOOWC) systems. Specifically, FD-GSM selects a subset of parallel OFDM modulators to transmit the same quadrature amplitude modulation (QAM) constellation symbol in the subcarrier level, while TD-GSM selects a subset of light-emitting diode (LED) transmitters to transmit the same time domain sample after OFDM modulation. Compared with the existing OFDM-based spatial modulation (SM) scheme, OFDM-based GSM can provide additional transmit diversity. For both FD-GSM and TD-GSM, maximum-likelihood (ML) detectors are employed to recover the spatial and constellation symbols. Moreover, TD-GSM usually requires a secondary direct current (DC) bias to work properly. The simulation results show that in a typical indoor 4×4 MIMOOWC system, OFDM-based TD-GSM outperforms OFDM-based FD-GSM by adding a proper secondary DC bias.

Keywords: Optical Wireless Communication (OWC), Multiple-Input Multiple-Output (MIMO), Generalized Spatial Modulation (GSM).

P1115

Joint Detection for Generalized Optical MIMO: A Deep Learning Approach

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In this paper, we investigate the performance of generalized optical multiple-input multiple-output (MIMO) systems using a deep learning-enabled joint detection scheme. In the generalized optical MIMO system applying both generalized spatial modulation (GSM) and generalized spatial multiplexing (GSMP), a fully connected deep neural network (DNN) is employed for the joint detection of spatial and constellation information. To efficiently train the DDN detector, the received signal after zero-forcing (ZF) equalization is taken as the input while the corresponding transmitted binary bits are used as the output. Our simulation shows that, in a 4×4 generalized optical MIMO system with two activated light-emitting diode (LED) transmitters, the ZF-DNN detector can achieve comparable bit error rate (BER) performance as the high-complexity joint maximum-likelihood (ML) detector in the high signal-to-noise ratio (SNR) region for both GSM and GSMP. Moreover, the ZFDNN detector achieves substantially improved BER performance than the conventional ZF-based maximum-likelihood (ML) detector. Due to the ability to eliminate error propagation, the performance gain of GSMP over GSM is greatly improved by using the ZF-DNN detector in comparison to the ZF-ML detector.

Keywords: Visible light communication, Generalized optical multiple-input multiple-output, Deep learning.

P1191

LED Nonlinearity Post-compensator with Legendre Polynomials in Visible Light Communications

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The nonlinear effect of Light-Emitting Diodes (LEDs) is one of the important factors that hamper the bit rate of Visible Light Communications (VLC). To mitigate the nonlinearity, we propose a Legendre-polynomials-based postcompensator derived from a post-distorter deduced by a physical based nonlinear LED model. We represent the formulation of the post-distorter with Legendre series expansion to ease the computation burden for training coefficients. Since only feed forward structure is embodied in the series representation, the coefficients of the proposed compensator are easy to access with adaptive algorithms of low complexity. To validate the effectiveness of our proposed model, we adopt Recursive Least Square (RLS) and Least Mean Square (LMS) algorithms to train the coefficients of our proposed compensator with the same iteration steps. In particular, RLS achieves lower Mean square Errors (MSEs) with faster convergence speed. Due to the relatively low complexity of these nonlinear algorithms, our proposed compensator is more actual for implementation on VLC hardware platforms like Field-Programmable Gate Array (FPGA).

Keywords: VLC, Nonlinearity, LED, Post-Compensator, Illumination, Communication.

P1348

Fault Detection of Air-spring Devices Based on GANomaly and Isolated Forest Algorithms

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Aiming at detecting the crack-type and bulge-type faults of the high-speed train's air-spring devices, a computer vision-based image fault detection method is proposed. In this paper, we select the GANomaly network model, which is sensitive to bulge fault features, and histogram of oriented gradients (HOG) feature extraction combines with the isolated forest algorithm, which is sensitive to crack fault features to detection failures. Based on the means of sliding window segmentation, the positive and negative samples are divided into a large number of small pictures. They are easier to detect abnormal features.

Then, these pictures are fed into the GANomaly network model. By comparing with the latent vector spaces obtained via encoding between positive and negative samples, bulge-type faults can be detected. HOG features are extracted from the small pictures, utilizing the isolated forest algorithm to detect crack type faults. Finally, marking a small picture with the highest anomaly score in the original image to complete precise location of fault object. or Math in Paper Title or Abstract.

Keywords: Air-Spring, GANomaly, Hog Feature, Isolated Forest Algorithm.

P1143

Collaborative Edge Network Research and Design Based on Ant Colony Algorithm for IoT

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IoT connections emerge exponential growth trend, which poses a serious challenge to cloud computing due to the limit of network bandwidth. Edge computing provides a promising solution. However, the computing power of edge side isn't enough to complete large scale tasks. Hence, to solve computing power shortage, a collaborative edge network (CEN) model is proposed, including system model and network communication model. Further, to estimate the performance of CEN, we design and implement ant colony algorithm to schedule tasks for IoT scenarios.

The simulation results show, as the mobile devices increase to 1500, the CEN reduces significantly average task complete time by 90% and task failure rate (TFR) by 10% compared with OnlyEdge. And the CEN reduces sharply TFR by 70% compared with OnlyCloud. As a consequence, the comprehensive performance of CEN is leading, which has more powerful access ability to serve enormous IoT devices.

Keywords: IoT, Cloud, Edge Computing, Collaborative Edge Network, Ant Colony Algorithm.

P1145

Achievable Rate of MIMO-OFDM VLC over Low-Pass Channels

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Visible light communication (VLC) is a short-range optical wireless communication (OWC) utilizing white light-emitting diode (LED) lighting, so that the VLC systems can provide both illumination and communication. Multiple-input multiple-output (MIMO) is an attractive technology to efficiently improve the achievable rate of VLC with multiple LED luminaries which experience a low-pass effect in practical channels. In this paper, we investigate the performance of MIMO-VLC over three general low-pass channels, including exponential, firstorder and Gaussian low-pass channels. Over frequency domain, two power loading strategies for multi-subcarrier orthogonal frequency division multiplexing (OFDM) are considered, namely uniform power loading and water-filling power loading. Expressions on the achievable rate to the corresponding link power budget and bandwidth are derived. Low-pass MIMO-OFDM VLC with a matrix channel decomposition has not extensively been treated theoretically in literature, to the best of our knowledge.

Keywords: MIMO, OFDM, VLC, Low-pass Channel, LED, Achievable Rate, Power Loading.

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P1022

Fault Feature Selection of Subway Plug Door Based on ReliefF and BGWO

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In view of the problem that the characteristic extraction of subway plug door fault diagnosis is too high, which leads to low diagnostic accuracy, a mixed feature selection method based on ReliefF algorithm and BGWO (binary grey wolf optimizer, BGWO) was proposed. Firstly, multiple domains feature extraction were carried out on the collected current signal of the subway plug door motor, and an original fault feature set describing the subway plug door fault was obtained. Afterwards, the ReliefF algorithm was used to evaluate the extracted original fault feature weights and screened out the less relevant features. Finally, the classification error rate of GWO (grey wolf optimizer, GWO)-SVM (support vector machine, SVM) is used as the fitness value, and BGWO is used as the feature selection algorithm to perform feature selection on the feature subset obtained by the ReilefF algorithm. The data collected in a Metro Depot in Jiangsu Province is used as the original data set for verification. The experimental results show that the method can screen out low dimensional fault feature sets with high correlation, low redundancy and high fault identification, it can effectively improve the accuracy of subway plug door fault diagnosis.

Keywords: Subway plug door, ReliefF, BGWO, GWO, SVM, Feature Selection, Fault diagnosis.

P1150

Face Image Based Automatic Diagnosis by Deep Neural Networks

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In this paper, we use ResNet based networks for the automatic diagnosis of the Turner Syndrome (TS) by facial images. The TS is a common sex chromosomal disorder, which is due to the total or partial absence or structural abnormality of the X chromosome. Nowadays, the diagnosis of the TS mainly depends on peripheral blood lymphocyte chromosome karyotype analysis, which is time consuming. For inexperienced doctors, it is difficult to diagnose the TS only based on facial features, and there may be missed and inaccurate diagnosis. In order to help the TS patients to get timely diagnosis, we design and train ResNet-based networks to recognize patients' facial features, and build an intelligent system for automatic diagnosis. We evaluate the performance of the ResNet-based networks by sensitivity, specificity, and accuracy. We increase the average sensitivity from 67.6% to 91.54%, average specificity from 87.9% to 98.52%, compared with the AdaBoost method with local features. In the future, we aim to set up the intelligent system on a smart-phone to achieve fast and convenient screening of the TS at an early stage.

Keywords: Deep Neural Networks (DNNs), Turner Syndrome (TS), Facial Images, Automatic Diagnosis, ResNet.

P1183

Deep Learning Based Load and Position Identification of Complex Structure

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Load identification is crucial for structural health monitoring. However, the traditional load identification methods based on the system response function. These methods calculate load using the inverse solution of structure dynamic response and system characteristics. Therefore, the traditional methods are only applicable to linear structures, and have some shortcomings such as ill-posedness and huge computational cost. In this paper, a deep learning based identification method is proposed to identify the static load amplitude and position of bulkhead plate rapidly. Firstly, the loading experiment is carried out. The raw signal is preprocessed by normalization and temporal segment. Secondly, we design the Bi-directional Long Short-Term Memory and Convolutional neural network (BiLSTM+CNN) to realize static load identification. Finally, the model is applied to the identification of dynamic loads to prove its generalization capability. It is demonstrated that the proposed deep learning model reveals a fast convergence and a high degree of accuracy in the identification of the load and its position. Moreover, the model can be applied to dynamic load identification.

Keywords: Deep Learning, Load And Position Identification, Bidirectional LSTM.

P1370

The Early Prediction of Lithium-Ion Battery Remaining Useful Life Using A Novel Long Short-Term Memory Network

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Accurate prediction of the lithium-ion battery remaining useful life can effectively manage the lithium-ion battery health. Using the early cycle data to predict the remaining useful life can reduce consumption and detect battery failures earlier, but it is still a great zchallenge due to weak and high dimensional nonlinear feature data of the early cycle. In order to solve this issue, this paper proposes a Long Short-Term Memory (LSTM) model that combines the idea of Broad Learning System (BLS), called BLS-LSTM, to accurately forecast the lithium-ion battery remaining useful life by using early cycle data. Firstly, according to the BLS idea, more effective feature nodes are obtained by performing mapping operations and enhancement operations on input features. Secondly, the characteristic nodes are input into the LSTM as new input nodes to predict the remaining useful life of the lithium-ion battery. Finally, the proposed model is validated with different early cycle data and compared with other methods. The results show that the BLS-LSTM model has better prediction performance and higher accuracy in the early prediction of the remaining useful life.

Keywords: Lithium-Ion Battery, Remaining Useful Life, Early Cycle Data, Long Short-Term Memory, Broad Learning System.

P1148

Interpretation of DGA for Transformer Fault Diagnosis with Step-by-step Feature Selection and SCA-RVM

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Oil-filled transformer is one of the important devices in power grid. To enhance the accuracy of transformer fault diagnosis and to ensure the stable performance of power system, an initial feature set, composed of the volume fraction of the seven dissolved gas and the constituted twenty-eight-set of dissolved gases selected by the step-by-step feature and SCA-RVM, is raised by analyzing the dissolved gas in oil. Then the ReliefF algorithm is used to select the sensitive features to be fused later. After that, the redundancy of the fused features is eliminated by the kernel LDA (KLDA), and lastly the step-by-step features are fed into the SCA-RVM diagnosis model. The result shows that, the accuracy of the diagnosis model can reach as high as 97.01%. Therefore, with the superior accuracy, this model can provide some references in transformer fault diagnosis.

Keywords: Fault Diagnosis, Transformer, Step-by-step Feature, SCA, RVM.

P1342

Dual Redundancy Fault Diagnosis and Reconstruction System of Sensors Based on BP Neural Network

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Aircraft braking system is the key to ensure the safety of aircraft take-off and landing, and it is the final safety barrier of flying. In the aircraft brake system, pressure sensors are installed. However, the sensor itself is fragile and sensitive, which is prone to failure in the harsh flight environment. If the fault of the sensor itself is not handled well, giving the wrong indication may lead to serious consequences. As the input of the brake control system, the research of fault diagnosis and reconstruction technology for sensors is helpful to improve the reliability and safety of the control system. In this paper, a dual redundancy fault diagnosis and reconstruction system based on BP neural network is designed. The system can diagnose the fault of the sensor signal, reconstruct the fault sensor signal, and output the most appropriate fault free value to the subsequent control system to ensure the normal operation of the control system. The signal of pressure sensor in aircraft brake system is simulated and analyzed. The simulation results show that the designed network training error is basically less than 0.05Mpa (0.5%), and the local error is less than 0.15Mpa (1.5%). In the case of a paranoid failure of the pressure sensor, the decisionmaking module can realize the function of fault diagnosis and reconstruction, and output a fault-free signal, which proves the effectiveness of the method.

Keywords: Sensor, Fault Signal Diagnosis, Fault Signal Reconstruct, BP Neural Network, Dual Redundancy.

P1371

Transformer Fault Diagnosis Based on BP Neural Network Optimized by The Strongest Crow Search Algorith

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In order to improve the accuracy of transformer fault diagnosis, a transformer fault diagnosis model based on the Strongest Crow Search Algorithm(SCSA) to optimize BP neural network is proposed. In the SCSA-BP fault diagnosis model, adaptive weights are introduced to coordinate the global and local search capabilities of the Crow Search Algorithm(CSA). The crazy factor is introduced to increase the diversity of the crow population and prevent individual crows from falling into the local optimum. Bidirectional Random Optimization(BRO) is added to reduce the amount of nonessential exploration by the crow and to improve the search efficiency of the crow. SCSA is used to optimize the weights and thresholds of the BP neural network to avoid the premature problem of the BP neural network. Simulation calculations show that the accuracy of the transformer fault diagnosis of the SCSA-BP model is 8.955% and 4.478% higher than that of the PSO-BP and CSA-BP diagnosis models, respectively.

Keywords: Transformer Fault Diagnosis, Crow Search Algorithm, Adaptive Weight, Crazy Factor, Bidirectional Random Search.

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P1059

Parallel and Pipelining design of SLAM Feature Detection Algorithm in Hardware

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Simultaneous Localization and Mapping (SLAM) is a system used to achieve autonomous positioning and navigation. Feature detection is an important part of a SLAM system as fast and robust image matching is required for the task. A typical feature detection algorithm called Speeded-Up Robust Features (SURF) is used in a robot SLAM system with Moving Object Detection (MOD). This paper describes a modified feature detection algorithm based on Field Programmable Gate Array (FPGA) hardware. The paper focuses on implementing the software algorithm on a hardware platform. The advantage of the parallel and pipelining design of FPGA is fully applied to highly improve the performance and efficiency of the system. By using the FPGA hardware platform, the algorithm can also be implemented easily in an FPGA-based SLAM system afterward to finally use for System-On-Chip (SoC) applications.

Keywords: Pipelining, SLAM, SURF, FPGA, Floating-Point Arithmetic.

P1116

Fault Diagnosis of Train Clamp Based on Faster R-CNN and One-class Convolutional Neural Network

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In recent years, Chinese high-speed railway ushered in a great development. With the high-speed railway operation gradually gets busy, the traditional method of relying on manual inspection of train fault has been unable to keep pace with the pace. As a key part of the train, the rod and spring components of clamp is essential for the safe and smooth operation of the train. In this paper, a novel method combining Faster R-CNN and One-class Convolutional Neural Network (OC-CNN) is proposed for fault diagnosis of the clamp part on train. Firstly, the rod and spring on the clamp part are located by Faster R-CNN, and the rod component is detected to determine whether there is any abnormality. Meanwhile, the spring area is cropped from the clamp part picture and resized as a fixed size. Then, the image contains spring area is feeded into the OC-CNN algorithm which is trained by positive samples and fine tuned by negative samples to determine whether there are cracks in the spring.

Through specific experiments, the conclusions show that this method is effective and it surpasses the other three types of combined methods, namely You Only Look Once version-4-tiny(YOLOv4-tiny) and OC-CNN, Single Shot Multibox Detector 512 (SSD512) and OC-CNN, as well as Nanodet and OC-CNN.

Keywords: Faster R-CNN, OC-CNN, Fault Diagnosis, Computer Vision.

P1136

Defects Detection of Dispensing Products With an Improved ICP Algorithm

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To solve the low efficiency, low precision, and high cost of detection in dispensing manufacture, a novel method based on machine vision combined with the optimized iterative closest point(ICP) algorithm is proposed in this paper. According to the characteristics of the dispensing products, Hough transform is selected to extract geometric features of glue points. Then, we choose template matching as coarse matching before ICP matching and find the alignment points for ICP matching to improve the efficiency and accuracy of ICP algorithm. The results of the experiment indicate that this method can accurately detect position deviation and geometric defects and its detection rate of products reaches 91.8%.

Keywords: Dispensing, Defects Detection, Hough Transform, Optimized ICP Algorithm.

P1193

Feature Point Screening For Image Matching

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Generally not all feature points contribute equally to feature matching. Stable, unique and salient feature points are helpful in efficient and accurate image matching. We propose three criteria for screening feature points, which are stability, uniqueness and saliency criterion. Based on stability criterion, robust and stable feature points can be preserved.

According to uniqueness criterion, feature points with repeated features would be removed. And points with distinct characteristic information can be retained in accordance with saliency criterion. By eliminating feature points that do not meet these criteria, image matching can be more efficient and accurate. The screening criteria are incorporated into common matching algorithms to verify its effectiveness. Experimental results show that the feature point screening criteria proposed can improve the matching accuracy, repetition rate and matching speed over versatile scenario.

Keywords: Image Matching, Feature Point Screening, Stability Criterion, Uniqueness Criterion, Significance Criterion.

P1323

An Evaluation of Machine Learning Frameworks

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Artificial Intelligence (AI) and Machine Learning (ML) have become increasingly important for any organization that wants to stay competitive and speed up its processes. However, while organizations can choose from a variety of machine and deep learning (DL) frameworks, it is important to remember that these frameworks serve very different purposes. Therefore, the choice of a framework adapted to your needs is a decision of the utmost importance. In this article, we present an evaluation of some of the most popular machine and deep learning frameworks developed, based on an image recognition task.

P1068

Visual Measurement of Levitation Gap in Maglev Ball System Based on Pixel Area

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The levitation control system is a key part of maglev train. The measurement of levitation gap plays an important role in the suspension system.

Traditional gap sensors have some disadvantages such as high power supply voltage, temperature influence and measurement distance limitation. In this paper, a method is designed on visual measurement of levitation gap. The maglev ball system is taken as the research object. We first obtain the original high-definition images of the ROI(region of interest) in the levitation gap. Then, the pixel area in the ROI of levitation gap is obtained by calculating the number of pixel points whose results are ”1” in the binarization image. Finally, the pixel area is calibrated with the actual gap distance and the actual gap distance is calculated. This method calculates the actual gap according to the image pixel area in the ROI of levitation gap. It has high measuring accuracy and strong antiinterference ability, which could effectively remove the asymmetric interference in the ROI of levitation gap, locating and alarming the interfered fault position.

Keywords: Magnetic Levitation Gap, Machine Vision, Image Processing, Calibration.

P1240

Video Summary Generation Based on Density Peaks Clustering with Temporal Characteristics

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Video summary is a new content-based video compression technology, which can effectively find important information from the video and eliminate redundant data in video. The density peaks clustering (DPC) can quickly find the density peaks of datasets of arbitrary shapes and efficiently allocate data. In order to apply it to video summary generation, we consider the temporal characteristics of the video, and introduce it into the DPC algorithm, and propose an improved DPC algorithm with temporal characteristics (called T-DPC), which is applied for the Hue histogram clustering of video frames, and the video shot is segmented based on the clustering results. In the keyframe selection stage, calculate the similarity between each frame and its cluster center, and the entropy of each frame, then select the frame with the largest linear combination of entropy and similarity in each category as the keyframe. At the same time, the histogram intersection method is employed to remove similar frames in the keyframes to generate video summary. The proposed method in this paper is evaluated with 50 videos in the open video library. The experimental results show that the accuracy of the video summary generated by our method is higher than that of OV, STIMO, and VSUMM1, but not as good as DT and VSUMM2. The recall rate is higher than the OV, DT, and VSUMM2, the same as the STIMO, and slightly lower than the VSUMM1.

The F values are all higher than the comparison algorithms OV, DT, STIMO, VSUMM1 and VSUMM2.

Keywords: Video Summary, Density Peaks Clustering, Shot Segmentation, Keyframe Extraction, Information Entropy.

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P1347

Background Separation Based on Dual-Weighted Robust Principle Component Analysis

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Robust principal component analysis (RPCA) is a powerful tool for solving background separation problems. However, the popular RPCA model doesn't make useful of the prior rank information in the background separation application, which usually leads to poor performance. To solve this issue, a new dual-weighted robust principal component analysis (DWRPCA) is proposed based on the prior rank information of the low-rank matrix and the sparsity of the sparse matrix. The singular values are weighted to encourage the target rank constraint of the lowrank matrix, and the sparse matrix is reweighted to enhance its sparsity. Experimental results show that the proposed dualweighted RPCA model leads to high accuracy of background separation, and high robustness for a variety of complex scenes, in comparison with the existing methods.

Keywords: Background Subtraction, Robust Principal Component Analysis, Low-Rank Matrix, Sparsity.

P1351

Histogram-based Fuzzy C-Means Clustering for Image Binarization

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The goal of image binarization is to classify the pixels into black and white correctly. Finding a threshold to binarize the image effectively is the essence in this study. This paper introduces a new algorithm for image binarization based on clustering. The algorithm computes on the histogram and uses the membership partition based on the distance between pixels within local spatial neighbors and clustering centers to accelerate the binarization procedure. Then the weighted factor is introduced to balance the noise-immunity and details. The proposed method combines the global and local ideas in the conventional algorithms. Compared with state-of-the-art algorithms, the proposed algorithm can universally obtain a robust effect for the images within distinct features, especially for the precision images.

Keywords: Image Binarization, Local Spatial Information, Fuzzy C-Means Clustering.

P1399

A Text Correction and Recognition for Intelligent Railway Drawing Detection

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In current train control system, there are manydrawings that need to be identified manually. This approachleads to many problems, such as misidentification and low eiciency. It is diicult to recognize these drawings automatically because the text on them often has a series of changes, likerotation, tilt, font changes and close to lines. To solve thisproblem, we divide the task into two parts: text recognitionand graphical symbol recognition. This article focuses on textrecognition. We use aerial detection technology to classify anddetect graphical symbol and text, followed by choosing BILSTM to conducting sequence modeling and using convolutionalrecurrent neural network (CRNN) iterative training to focuson single word rotation, including tilting,

noise-addition, andblurring post-processing. So that the training model can cope with complex scenario and improve the recognition rate of texton drawings. Finally, RESNET is applied to CRNN featureextraction network, and CRNN outputs the recognition and detection results in sequence according to the detection sequence,achieving entry-level detection, and the text recognition ratereaches 98.36%.

Keywords: Character Correction, Character Recognition, Railway Drawing, Deep Learning.

P1412

LERANet: Low-light Enhancement Network based on Retinex and Attention

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The performance of vision based applications is often limited by low-light imaging environments. While various methods have been proposed to enhance image contrast, noise is inevitably amplified. In addition, most methods result in over-enhancement in bright regions. In this paper, we consider a convolutional neural network, named as LERANet, to decouple a dark image into reflectance and illumination, which can thus enhance contrast and reduce noise. An attention module is also integrated in the network to avoid over-enhancement. Experimental results demonstrate the effectiveness of the proposed LERANet on noise suppression and detail preservation. In addition, both subjective and objective comparisons with state-of-the-art algorithms indicate the superiority of the proposed method.

Keywords: Low-light Enhancement, Retinex, Attention, CNN.

P1416

Crack Detection on Aircraft Composite Structures Using Faster R-CNN

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Detecting imperfection and cracks of composite internal surfaces on aircraft is an arduous task due to accessibility problem, dark color surface, limited space and poor lightings. In this paper, we present a deep learning framework based on Faster R-CNN for crack detection on the internal composite surfaces of civil transport aircraft.

To enhance recognition efficiency, a Faster R-CNN network is designed. To overcome the constraint of limited sample images, image augmentation method is developed. Experiment shows that the overall performance and robustness of the proposed system could meet our project requirements.

Keywords: Image Recognition, Feature Extraction, Region Proposal Network, CNN, R-CNN, Fast R-CNN.

P1422

Improving Recognition Performance for Low-Resolution Images Using DBPN

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Artificial Intelligence (AI) has evolved and been used for many different purposes. Python is one of a well-known language when it comes to AI due to the presence of the libraries like TensorFlow, Keras and Pytorch. The Aim of the project is to recognize faces from low resolution (LR) images, small size or poor-quality images with varying pose, illumination, expression, etc. This issue has received much attention due to the increasing demands for long distance surveillance applications. In this paper, an overview on the problems and the expected progress are presented. A solution based on Deep Back-Propagation Network (DBPN) is proposed to improve accuracy of the face recognition by using super resolution(SR) approach, which include detection / plotting of the facial-features/landmarks in an image, then using this landmark to align the image, training on a state-of-art Neutral Network for SR of LR image, etc. Experimental results shows that the proposed systemachieved8.41 % precision and 8.38 % recall rate for a 4425 persons dataset.

Keywords: CCTV, CNN, GAN, FAN, DBPN, PSNR, SR Image, LR Image.

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P1218

The Optimization Strategy of Tests for Fault Isolation Based on Rollout Algorithm

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The traditional fault isolation strategy based on the rollout algorithm will increase the algorithm time complexity and use too many test points. The optimization strategy of tests for fault isolation based on rollout algorithm can solve these problems, and make the final optimization result is still better than the normal rollout algorithm. This optimization strategy not only makes the rollout algorithm effective, maximizes the system fault isolation rate, but also reduces the time complexity of the algorithm, reduces the use of unnecessary tests, simplifies the complexity of the system, and improves the compatibility of the algorithm for complex systems. The principle of this optimization strategy is to perform fault isolation operations on all tests before using the rollout algorithm, and then use the rollout algorithm to sort the tests after selecting the necessary tests. Finally, the theoretical and case analysis results prove that the optimization strategy can use the least tests under the premise of ensuring the maximum fault isolation rate, reduce the time complexity of the rollout algorithm, and is suitable for optimizing the fault diagnosis of complex systems.

Keywords: Rollout Algorithm, Test Optimization, Fault Isolation, Binary Test.

P1300

Traffic PowerFlow:A Time-space Network based Program for Optimal Traffic Power Flow Analysis

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With transportation electrification, the power systems and traffic systems are more and more interdependent on each other. To analysis this interdependence more concisely, an optimal traffic power flow problem is formulated with the help of alternating current (AC) optimal power flow and vehicle routing problem (VPR). These two problems are integrated into an unified time-space network (TSN), as a mixed integer programming problem. To solve the meso-scale level problems with multiple oriented destination pairs, the random permuted alternating direction method of multipliers is adopted to solve the formulated problem distributed. The case study is performed on the modified IEEE-30 and Sioux fall networks, and the results verify the effectiveness of the proposed scheme.

Keywords: Power System, Electric Vehicle, Vehicle Routine Problem, Time-Space Network.

P1146

Research on Fault-phase Selection of New High-Speed Railway Continuous Power Line Based on Wavelet Transform

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On the basis of constructing a new high-speed railway distribution network structure, according to the actual operation of Xi-Cheng passenger dedicated line, a simulation model of power cable continuous line between two distribution stations is built on MATLAB / Simulink platform. Based on this model, the operation status of the system connected with power electronic transformer is simulated and analyzed, and a lowpower experimental platform is built for experimental verification. The method of high-speed fault-phase selection of transmission line based on wavelet transform is applied to faultphase selection of new high-speed railway continuous power line. In this method, the detected transient fault current is transformed into a module component through the phase-mode transformation, and binary discrete wavelet transform (DWT) was carried out on the fault current mode component by using db5 wavelet basis in MATLAB wavelet toolbox, then the maximum modulus was obtained as the phase selection criterion for phase selection. According to the characteristics of the continuous power line and the simulation results, the phase selection criterion is modified and improved.

A large number of simulation experiments show that this method can realize phase selection under different fault types, different fault distances and different fault grounding resistance in new high-speed railway continuous power line.

Keywords: Continuous Power Line, Wavelet Transform, Faultphase Selection, Modulus Maxima.

P1167

Research on EV Charging Station Capacity under Multi-price Scale

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In order to deal with the problems that may arise during the reservation charging process, this article proposes to set up emergency charging piles in the fast charging station and implement a multi-price scale charging mechanism, then, explain the corresponding EV charging and queuing methods. Under the multi-price scale, charging station revenue and user satisfaction were quantitatively characterized in this article, an optimization model was established to solve the optimal ratio of ordinary piles to emergency piles in the charging station. This article analyzes the impact of this ratio on charging station revenue and user satisfaction combined with calculation examples. The results show that multiple price scales has a certain guiding effect on the charging behavior of users, and the reasonable configuration of the number of ordinary piles and emergency piles can increase the revenue of charging stations and improve user satisfaction. The conclusion obtained in this paper can provide guidance for determining the capacity of charging stations that take into account the diverse charging needs of electric vehicle users, user satisfaction and the net income of existing charging stations under multiple price scales, and can provide new ideas for the development of new operating methods for charging stations.

Keywords: Reservation Charging Mechanism, Emergency Charging Piles, Multi-Price Scales, Charging Station Capacity, Optimization.

P1168

Research of Fault Diagnosis Method for New High-speed Railway Single Power Distribution Station Based on Bayesian Network

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This paper presents a Bayesian network reasoning method for fault diagnosis of high-speed railway single power distribution station. In this method, the fault model of Bayesian network is established according to the causality of fault element, protection and circuit breaker, using the alarm information received by the high-speed railway distribution SCADA system, the fault element and fault action protection or circuit breaker can be inferred and diagnosed on the model. This paper obtains the actual electrical wiring and circuit breaker protection configuration of a high-speed railway distribution station through investigation, Bayesian network modeling and reasoning were carried out on GeNle software platform, The feasibility and correctness of the method are verified.

Keywords: Bayesian Networks, High Speed Railway Power Distribution, Fault Diagnosis.

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Date	1 – 14 August 2021

P1197

Transformation from System Model to FACE Data Model Based on Metadata Mapping

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Aiming at the problems of long development cycle, poor reusability and portability in avionics software development, this paper proposes a development process based on MBSE(Model-based systems engineering) and FACE(future airborne capability environment) architecture. At the same time, the differences between SysML model and FACE data model lead to the incoherence of development process.

Therefore, the mapping transformation method from SysML model to FACE data model is designed based on metadata model mapping Law.

Keywords: Avionics Software, MBSE, FACE Architecture, Metadata, Model Mapping.

P1257

Adaptive Gait Generation Based on Pose Graph Optimization for Lower-Limb Rehabilitation Exoskeleton Robot

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The lower extremity rehabilitation exoskeleton robot can achieve rich functions through well-designed software and hardware control systems, and bring the gospel to patients with stroke in society. Exoskeleton in the current market has problems such as poor human-computer interaction and a single rehabilitation training scene. Based on the exoskeleton system, this subject studies the human, machine, and environment interactive control strategies of the independent exoskeleton and the adaptive weight-reduction system of the exo-skeleton rehabilitation robot. These studies will significantly improve the human-computer interaction of exoskeleton and expand the rehabilitation training scene of exoskeleton. The innovation of this subject is to design a complete set of independent exoskeleton software and hardware systems, and to design an efficient real-time sensing algorithm for the independent exoskeleton system, and to propose an adaptive trajectory generation algorithm that can adapt to different terrain walking to complete Human, machine, and environment interactions of the exoskeleton system. For the bench-type exoskeleton system, we designed an adaptive weight loss system based on force control to help patients with severe illness to complete rehabilitation training.

Keywords: Exoskeleton Robot, Environment Perception, Human-Robot Intraction, Gait Generation.

P1271

Mission Oriented Flocking and Distributed Formation Control of UAVs

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This paper presents the development of a novel autonomous search, detect and task execution model for Unmanned Aerial Vehicle (UAV) distributed formations. This work studies the problems of formation flocking, tracking and collision avoidance for a distributed formation of UAVs by use of multi-agent graph theory and artificial potential field approach in the first stage, based upon the proposed algorithm the second stage implements target search, detection and mission execution tasks, while the last stage carries out the re-flocking of the vacant UAVs. In order to validate the model, simulations were performed for every stage of the process to evaluate the desired flocking and task execution performance of the distributed formation. Finally, the results obtained from the simulations indicate that UAVs using the proposed model are able to execute the mission as per desired performance goals.

Keywords: Distributed formation control, Formation flocking, Artificial potential field, Unmanned Aerial Vehicles (UAVs), Swarm UAVs, Multi-agent graph theory.

P1325

Performance Analysis and Comparison of Four Conventional Multi-objective Optimization Algorithms

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With the development of Artificial Intelligence and Big Data, more and more heuristic multi-objective algorithms are applied to the training process of data sets. In this paper, four heuristic multi-objective optimizations which were widely used in the data set training in recent years, are selected for the performance analysis and comparison.

Through the comparison and analysis of the performance index for these algorithms on the benchmark problem, the advantages and disadvantages of these strategies in ensuring the convergence of the algorithm and maintaining the diversity of the solution sets are systematically expounded. The simulation results show that these algorithms have their own advantages and disadvantages in solving different specific problems, and the setting of the parameters and the initialization of the solution sets will have a great impact on the performance of the algorithm. Moreover, the different methods have the different abilities in maintaining the convergence and diversity of the solution sets. Although the complex optimization method has a better solution effect, the calculation time cost is higher. In practical application, it is necessary to select the appropriate algorithm flexibly according to the actual problems and conditions.

Keywords: Multi-objective Optimization, Convergence, Diversity, Performance Analysis, Comparison.

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P1082

Yaw Stability Control for 6WD Unmanned Vehicle on Split-mu Road Using Sliding Mode Algorithm

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The control of unmanned vehicle systems are involved with uncertain road condition, uncertain load quality as well as unstable motor control system. In this paper, a sliding mode control strategy for the torque control of six-wheels vehicles are proposed to maintain a fixed velocity and meanwhile track a straight-line. Low-level controllers and high-level controllers are designed and conducted under six-wheel driving mode. The experimental results validate the effectiveness of our proposed control scheme.

Keywords: Sliding Mode Control, Six-wheels Vehicle, Tracking Control.

P1223

Effectiveness Analysis of Evaluating Continuous Commutation Failure With Short Circuit Ratio

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The continuous commutation failure (CCF) of a line-commuted converter (LCC) based high voltage direct current (HVDC) transmission system will lead to long-term power imbalance of AC systems, which seriously threatens the safe and stable operation of AC systems. At present, the short circuit ratio (SCR) is widely used to evaluate commutation failure recovery characteristics of HVDC systems. In order to verify the effectiveness of the SCR in evaluating the risk of the CCF, the factors influencing the accuracy of the SCR are studied based on a simplified single-infeed HVDC system model. The analysis results show that the accuracy of the SCR is seriously reduced if there are a large number of loads near the LCC.

Keywords: Continuous Commutation Failure, Short Circuit Ratio, Effectiveness Analysis, Single-Infeed HVDC System.

P1287

Low-Frequency Oscillation Analysis of Train-Network System with Different Types of Trains Connected

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The low-frequency oscillation (LFO) of electrified railway is largely related to the grid-side converters of the train. The mixed operation of different types of trains with different control methods and parameters of the grid-side converters brings new challenges to system stability. In fact, Dq-domain control (DQDC) and phase-domain control (PDC) are frequently used in train grid-side converters. This paper proposes a dq impedance modeling method of PDC train, which is in the same domain as the model of DQDC train, so that a unified train impedance model (UTIM) for the trains with these two control strategies can be established in dq-domain. Then, the generalized Nyquist stability criterion (GNSC) is used to study the LFO. The influence of the parameter on the system stability in the case of two types of trains connected is revealed, and will be different from the system with only one type of trains connected. Finally, time-domain simulations verify the correctness of the theoretical analyzing conclusions.

Keywords: Train-Network System, Low-Frequency Oscillation, Unified Train Impedance Model, Stability Analysis.

P1293

A Hierarchic Control Strategy for Reliability Enhancement of PFCs in Co-phase TPSS

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As the core component of co-phase traction power supply system (TPSS), the reliability evaluation and reliability optimization of power flow controllers (PFCs) are crucial to its safe operation. In this paper, the failure rate calculation model is adopted to evaluate the reliability of the PFCs. To enhance the reliability of PFCs, a novel hierarchic control of PFCs under the third compensation strategy is proposed in this paper. In the high-load area, all of the PFCs are operated simultaneously by the average-current sharing control while in the light-load area part of the PFCs unit is operated by turns to decrease the total power loss of converters. Taking the co-phase PFCs of the Shayu traction substation as an example, the effectiveness of proposed strategy is demonstrated. Results are shown that the failure rate of IGBT modules is reduced by 42.16% and the power loss is decreased by 11.75%.

Keywords: Co-Phase Traction Power Supply System, Power Flow Controllers, The Third Compensation Strategy, Hierarchic Control.

P1303

Supplementary Damping Controller Design of DFIG With Mode-based Damping Torque Analysis Method

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This paper introduced the design method of supplementary damping controller of DFIG with the mode-based damping torque analysis method. Firstly, the principle of the mode-based damping torque analysis method is stated. Then, the comparison of the mode-based damping torque analysis method and two traditional controller design methods, that is, the classical damping torque analysis method and the residue method, are illustrated. Through theoretical derivation, it can be seen that different from the classical damping torque analysis method, the mode-based damping torque analysis method takes the oscillation mode of the power system as the main analysis object directly, which reduced the amount of calculation greatly. In addition, in the controller parameter adjustment in closed-loop system, the "dynamic" mode-based damping torque indicator is theoretically more accurate than the "static" residual indicator. Finally, the modified two-area four-machine power system is used to determine the installation location and parameters of the supplementary damping controller of DFIG with the model-based damping torque analysis method, which demonstrated the correctness of the method.

Keywords: DFIG, Supplementary Damping Controller, Mode-based Damping Torque Analysis Method, Residue Method.

P1344

Low Voltage Ride Through of Voltage Source Converters With Droop Control

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In this paper, the transient stability of droopcontrolled voltage source converters (VSCs) is studied. Firstly, according to the rotor motion equation of a synchronous generator (SG), the large-signal model of VSCs is established. On this basis, the mechanism of transient instability of the converter during short-circuit fault is revealed through the equal area criterion (EAC). In order to ensure that the converter has low voltage ride through capability, the control mode is switched to vector current control by an adaptive mode parallel switching method. In the process of fault, the output current of the converter can follow the current reference value well and provide reactive power support to the grid. Finally, simulation and experimental results verify the effectiveness of the theoretical analysis.

Keywords: Droop Control, Voltage Source Converters(VSCs), Transient Stability, Low Voltage Ride Through.

P1383

Fault Prediction of Power Electronic Devices in Mobile UPS System

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As a source of emergency power supply, the safety and reliability of mobile UPS system has an important impact on the quality of the power supply. Power electronics are the core components of UPS system, and the failure of power electronic device will have a serious impact on the safe operation of the system. Therefore, to improve the reliability of UPS system and reduce the losses caused by component failure and module failure, failure prediction of power electronic device has an important theoretical research significance and practical value. Hence, power electronic device fault prediction of UPS system is studied based on support vector machine.

Keywords: UPS System, Power Electronic Device, Characteristic Parameter Extraction, Fault Prediction.

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P1401

Rapid Power Control and MPPT Method of Voltage Controlled Grid-connected Inverters In Very Weak Grids

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Compared with current-controlled grid-connected inverters (CCIs), voltage-controlled grid-connected inverters (VCIs) have shown stronger stability in very weak grids. Therefore, in the future power system with renewable energy as the main energy source, VCI has a wide application prospect. However, the power control bandwidth of VCIs is usually very low under very weak grids. It is difficult for the VCI to track renewable energy changes in time and may lead to DC side power imbalance or even DC voltage instability. First, this paper proposes a VCI rapid power control method based on pre-filtering control, which can effectively increase the VCI active power control bandwidth, and without affecting the control stability in the weak grid. Then, this paper proposes a corresponding MPPT control strategy, which can achieve MPPT efficiency equivalentto CCI even in the very weak grid and maintain DC voltage stability. Finally, experimental results validate the analysis and the proposed method.

Keywords: Voltage-Controlled Inverters, Weak Grid, Rapidpower Control, MPPT.

P1227

Influence Factors Analysis of Transient Power Angle Instability Caused by Commutation Failures

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In China, line-commuted converter (LCC) based ultra-high voltage direct current (UHVDC) transmission projects are main technical means for power transmission from west to east. However, due to high voltage level and large capacity of LCC-UHVDC projects, commutation failures of LCCs have seriously threatened power system stability. The commutation failure of a LCC-UHVDC system will lead to large-scale power flow transfer of the sending end grid, which will cause the power angle of two clusters to pull apart and threaten the power angle stability of the weak sending end grid. Based on a simple sending end power grid model composed of two generators, this paper analyzes the influence factors of the peak value and the damping ratio of the power angle, and reveals the mechanism of power angle instability caused by commutation failures. Finally, based on the electromechanical simulation software PSS/E, the correctness of the theoretical analysis is verified in a modified two-area four-machine system.

Keywords: Commutation Failures, LCC-UHVDC Systems, Power Angle Stability.

P1295

An Accurate Linearized model of Synchronous Reference Frame Phase-Locked Loop

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Synchronous reference frame phase-locked loop (SRF-PLL) is a classical method to achieve grid synchronization in three-phase systems. And SRF-PLL has important influence on weak grids. Many linearized models have been addressed to describe PLLs. However, they have low dynamic accuracy in the case of frequency jump. To fill this gap, an accurate linearized model of SRF-PLL is proposed and the proposed model has good dynamic accuracy in cases of frequency jump and phase angle jump. In details, a nonlinear model of SRF-PLL is established. Then, a simplified model is obtained according to the accurate linearization technology. Compared with the traditional model of SRF-PLL, the proposed model has better dynamic accuracy, especially in the case of frequency jump.

Keywords: Linearization, Synchronous Reference Frame Phase-Locked Loop, Linearized Model, Dynamic Accuracy, Frequency Jump.

P1307

A Benchmark Model of Grid-Connected Conversion System for Control Interaction Caused Oscillation Problems

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The paper demonstrates a benchmark model to solve the latest oscillation problem that occurred in the power system with high proportion of renewable power generation. The oscillation problem is particularly related to the control interactions caused by power electronic devices. Hence, this model is simplified based on a grid-connected wind generation system. It shows the phenomena of sub-synchronous and supersynchronous oscillation under certain circumstances. The analytical techniques of the eigenvalue method and impedancebased method are both applied to this model which are demonstrated by the digital simulator (MATLAB Simulink). The model parameters are determined based on the Hami wind power system in Xinjiang, China. According to the simulation results, the model can present the sub-synchronous and supersynchronous oscillation phenomenon under certain conditions, which can be applied with different theoretical techniques.

Keywords: Benchmark Model, Sub-Synchronous Oscillation, Super-Synchronous Oscillation, Grid-Connected Conversion System, Control Interaction, Renewable Energy.

P1389

Analysis of Subsynchronous Oscillation Characteristics of Hybrid-Based Wind Farm Connected With Fixed Series Compensation System

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With the rapid development of new energy, the problem of power oscillation caused by large-scale wind farm access system has become increasingly prominent, such as the subsynchronous resonance between doubly-fed induction generator (DFIG) and fixed series compensation, which threatening the security and stability of the system seriously. Since there may not be a single type of wind turbine in the same wind farm, this paper aims to clarify whether there is interaction between different types of wind turbines in the wind farm, thus focuses on the subsynchronous oscillation (SSO) of a system that including DFIG based wind farm, direct-drive permanent magnet synchronous generator (PMSG) based wind farm and fixed series compensation. A linearization model of hybrid-based wind farm is established to analyze the influence of wind farm proportion, control parameters on the operation stability of the system. Based on the dynamic impedance model of hybrid-based wind farm, the mechanism of SSO is further revealed. A time-domain simulation model is built in EMTDC / PSCAD to verify the correctness and effectiveness of the theoretical analysis.

Keywords: Doubly-Fed Induction Generator, Direct-Drive Permanent Magnet Synchronous Generator, Fixed Series Compensation, Sub-Synchronous Oscillation, Impedance Characteristic.

P1406

Comparative Analysis of Two Kinds of Subsynchronous Oscillation of Direct Drive PMSG based Wind Farm Dominated by Inner Current Loop

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Aiming at the subsynchronous oscillation problem of direct drive wind farm in low operating conditions, the eigenvalue analysis method and impedance analysis method are used to analyze two kinds of subsynchronous oscillation problems caused by different current loop parameters of direct drive wind turbine group dominated by current inner loop control. The results show that: for the first kind of subsynchronous oscillation, the dominant influencing factors are the power grid strength and the current inner loop control parameters; with the decrease of the power grid strength, the current inner loop control parameters decrease, weakening the system damping, and the oscillation frequency gradually decreases; for the second kind of subsynchronous oscillation, the dominant influencing factors are the current inner loop control parameters, with the decrease of the power grid strength The damping of the system is weakened and the oscillation frequency increases slightly. In EMTDC/PSCAD, the time domainsimulation model of direct drive wind turbine group connected to AC power grid is built, which verifies the correctness and effectiveness of the theoretical analysis.

Keywords: Direct Drive Wind Farm, Subsynchronous Oscillation, Eigenvalue Analysis, Impedance Analysis.

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P1055

Remaining Useful Life Estimation of Battery based on MEKF

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With the wide application of lithium-ion batteries in the field of new energy vehicle, state of charge (SOC) estimation and remaining useful life (RUL) estimation have become important issues. This paper studies the state of charge estimation and RUL online estimation. Firstly, an experimental platform was setup and the battery cell experiment was conducted, which was used to bulid a battery model. Secondly, a multi-scale extended Kalman filter algorithm was proposed for SOC estimation and RUL estimation. Finally, based on the existing life cycle charge and discharge data, the proposed algorithm was evaluated, and can be effectively applied in practice.

Keywords: Second-order RC battery model, RLS(Recursive least squares), MEKF((Multiplicative Extended Kalman Filter), RUL(Remaining Useful Life), on-line Estimation.

P1062

Joint Estimation of State of Charge and Capacity of Lithium-ion Batteries in Electric Vehicle

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Considering battery aging and reducing CPU calculation pressure of electric vehicle, real-time assurance of the accuracy of power battery SOC and capacity is very important for the safety of electric vehicles. In this paper, a combined framework of battery SOC and capacity estimation is introduced based on equivalent circuit model. For the problem of traditional Kalman filter that only Gaussian noise can be filtered. An improved extended Kalman filter is proposed to estimate the battery SOC in real time.The accelerated aging experiment method is used to study the effect of the gray model in predicting battery capacity decline and the cumulative error of SOC estimation under battery aging. Through static and dynamic test experiments, the accuracy and robustness of the method proposed in this paper are verified.

Keywords: State of Charge, Capacity Prediction, Improved-Extend Kalman Filter, Grey Model.

P1066

Online Joint Estimation of SOC and SOP for Highrate Battery based on EKF

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Aiming at the problem of high precision and high safety estimation of state of power (SOP) of high-rate lithium-ion power battery in the application of special operation vehicle, this paper analyses the working characteristics of the high-rate lithium-ion power battery, and builds the second-order RC equivalent circuit model of the battery. The recursive least squares (RLS, Recursive Least Squares) algorithm is used to identify battery parameters online, and the SOC algorithm based on the extended Kalman filter and the SOP algorithm are used for joint estimation. This algorithm is used to solve the problem that the maximum allowable power of the actual battery caused by the degradation of battery life is difficult to calculate and even causes the problem of safe fire accidents. Combined with the correction algorithm in practical engineering, it ensures the efficiency and safety of the SOP estimation during the entire life cycle of the electric vehicle. This research has an important significant guiding in engineering practice.

Keywords: High-Rate Lithium-Ion Power Battery, SOP Estimation, Extended Kalman Filter, Joint Estimation.

P1052

SOC Estimation of Extended Kalman Filter Based on Hardware-in-the-Loop Simulation Platform

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This paper studies the extended Kalman filter SOC estimation based on the hardware-in-the-loop simulation platform. The extended Kalman filter is used as the method of SOC estimation. The modeling strategy is based on the lithium battery equivalent circuit. Since the normal operation of the battery has strong nonlinearity, it is selected The general nonlinear equivalent circuit model fully considers the charge and discharge rate and the ambient temperature, and uses the Fourier function to effectively fit the model parameters; the extended Kalman filter algorithm is used to estimate the state of charge of the battery, and through MATLAB simulation, The Kalman filtering algorithm based on the empirical formula is compared to improve the estimation accuracy and verify the feasibility and reliability of the algorithm.

Keywords: Lithium Battery, Battery Equivalent Circuit, State of Charge, Extended Kalman Filter.

P1069

Regrouping Optimization Method for Retired Batteries based on Particle Swarm Optimization Algorithm

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A large number of lithium-ion batteries retired from electric vehicles (EVs) need to be treated because nearly 80% of the capacity remains. However, the retired batteries have inconsistencies in capacity, state of charge (SOC), and internal resistance. If batteries are regrouped directly, the power and energy performance will be restricted. In order to improve the energy performance of the second-use battery pack, this paper studies the regrouping method of retired batteries. A semi-empirical model of LiFePO4 battery is used, and then a capacity fading model for the second-use battery pack considering inconsistencies is established. The maximum available Ah-throughput of the pack after regrouping is set as the optimization goal, and the particle swarm optimization algorithm (PSO) is used to search the optimal regrouping method. Simulation is employed to verify the method and the results show that the value of the maximum available Ah-throughput is about 8.2% larger than that of the traditional method. The proposed method is of great significance for guiding effect on the regrouping of retired batteries.

Keywords: LiFePO4 Battery, Second-Use, Battery Regrouping.

P1122

State Estimation of Lithium-Ion Battery at Different Temperatures Based on DEKF and RLS

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Lithium-ion power battery is the power source of many electronic control systems. The battery state of charge (SOC) and state of health (SOH) are very important to the safety and reliability of the electronic system. Therefore, highprecision estimation of battery SOC and SOH has become one of the current research hotspots in the battery field. In order to realize the state estimation of lithium-ion power battery, an equivalent circuit model of lithium-ion power battery is established. This article is based on the HPPC pulse experiment data and the second-order Thevenin equivalent circuit model. At different temperatures (0°C, 25°C, 45°C), the recursive least square (RLS) method is used to identify of parameters of the equivalent model circuit. The state equation and measurement equation of the double extended Kalman filter (DEKF) algorithm are used to estimate SOC and SOH. Finally, this article uses experimental data of the single cell to estimate the battery state. The accuracy and adaptability of the combination of least squares algorithm and dual extended Kalman filter are verified. This is of great significance for improving the safety, reliability and economic benefits of the battery system.

Keywords: Lithium-ion battery, State of Charge, State of Health, Battery Model, DEKF, RLS.

P1180

Modeling and Simulation of Fuel Cell Buses

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Fuel cell buses are powered by lithium batteries and fuel cells, according to the characteristics of the transmission structure and power source of a particular fuel cell bus, the mathematical models of the longitudinal dynamics, driver, demand torque, motor, fuel cell, and battery have been analyzed and established based on Matlab/Simulink. At the same time, a power-following real-time energy management strategy has been designed. After three sets of China heavy-duty commercial vehicle test cycles for buses and coaches were verified in a combined simulation, the results showed that the model of fuel cell bus better reflects the working characteristics, and the power distribution strategy can keep the fuel cell operating within a high efficiency range as much as possible.

The battery provides energy when there is insufficient power, absorbs excess power from the fuel cell, and simultaneously recovers the energy lost from braking. The charging state is also maintained within a certain range. In addition, the hydrogen consumption has a negative correlation with the initial charging state.

Keywords: Fuel Cell, Intercity Bus, Modeling and Simulation, Rule Control, Energy Management.

Session	SS12 Intelligent Computing and Pattern Recognition (1)
Date	1 – 14 August 2021

P1023

Fault Diagnosis of Subway Plug Door based on EEMD and Adaptive Feature Extraction

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Fault diagnosis of the subway plug door plays an essential role in the safe operation of the city subway. To improve the diagnosis accuracy of the subway plug door, fault diagnosis of the plug door based on Ensemble Empirical Mode Decomposition (EEMD) and adaptive feature extraction was presented in this paper. Firstly, EEMD was used for decomposition of raw data, and the intrinsic mode function (IMF) after decomposition was selected by correlation coefficient criteria. Then, the fault features in IMFs was extracted and the sensitive features among which was selected by the sensitive index. Finally, the faults were classfied by Gray Wolf optimized Support Vector Machine (GWO-SVM). The experiment with the measured data of a subway door shows that this fault diagnosis method can adaptively extract the relative optimal characteristic quantity, identify the normal state and four different fault states effectively with the recognition accuracy of 89.35%, which is valuable in the engineering application.

Keywords: Subway Plug Door, Fault Diagnosis, EEMD, Feature Extraction Algorithm, GWO-SVM.

P1090

A Method for Predicting the Quality of Slabs Based on GA-RF Algorithm

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In order to realize the prediction of continuous casting billet inclusions and provide guidance for actual production, a slab quality prediction method based on genetic algorithm and random forest (GA-RF) is proposed. Taking the continuous casting production data as the object, the sequential backward selection algorithm (SBS) is used to perform feature selection to remove redundant features, and a random forest algorithm model with genetic algorithm parameter optimization is established to predict the quality of cast slabs. The results show that the accuracy of the GA-RF model in casting billet quality prediction is 89.24%, which is better than the prediction accuracy of 78.25% of SVM and 85.84% of BP neural network. At the same time, compared with the grid search algorithm and the random forest model optimized by the particle swarm algorithm, the GA-RF algorithm has higher prediction accuracy and prediction speed.

Keywords: Slab Quality Prediction, Random Forest, Sequential Backward Selection, Genetic Algorithm, Feature Selection.

P1220

Research on Digital Imaging Simulation Method of Space Target Navigation Camera

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Based on the application scenarios of space target imaging simulation, this paper conducts modeling research on the digital imaging simulation method of space target navigation camera. According to the geometric positioning model and the optical characteristics of different materials, a model of the target geometry and optical characteristics was carried out. Finally, a digital imaging simulation software was designed and developed based on the OptiX engine.

Through the analysis of the image quality test and the speed test, it is verified that the digital imaging simulation method of the space target navigation camera can complete the imaging simulation task correctly and quickly.

Keywords: Imaging simulation, Optical characteristic model, Space target, OptiX.

P1238

Object SLAM with Dual Quadric Parameterization

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Conventional SLAM systems lack the ability to create semantically meaningful maps for scene understanding of robots. In this paper, we estimate a quadric surface for each object by detecting objects from different views and propose an object SLAM that uses dual quadric representations as 3D landmarks to overcome this limitation. A dual quadric can represent the position, orientation, size of an object compactly. We devise a geometric ellipse measurement model that addresses the problem of reconstructed object projection, and demonstrate how to integrate it into the SLAM system in order to jointly estimate camera poses and constrained dual quadric parameters. Our method is valuated on the public dataset. Experiments show the validity of creating maps with high-level information.

Keywords: Object SLAM, Semantic SLAM, Quadrics.

P1291

Stereo-based Terrain Parameters Estimation for Lower Limb Exoskeleton

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This paper is concerned with the problem of terrain parameters estimation for the lower limb exoskeleton. It is necessary for the lower limb exoskeleton to recognize terrain parameters in order to adjust the control law correspondingly when walking in different environments. We use a binocular camera to obtain binocular images and 3D point cloud by stereo matching and reconstruction. Since the exoskeleton usually moves in the sagittal plane, and slopes and stairs have the same shape in planes parallel to the sagittal plane, parameters can be estimated by the 2D projection onto the sagittal plane. The experiment is carried out to verify the effectiveness of the proposed method.

Keywords: Stereo Vision, Point Cloud Projection, Terrain Parameters Estimation, Lower Limb Exoskeleton.

P1387

Application of VMD Combined with CNN and LSTM in Motor Bearing Fault

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Traditional data-driven diagnosis methods rely on manual feature extraction and it is difficult to adaptively extract effective features. Aiming at the characteristics of nonlinear, non-stationary, and strong noise of rolling bearing faults, a novel intelligent fault diagnosis framework is proposed, which combines variational modal decomposition (VMD), convolution neural network (CNN) and long short term memory (LSTM) neural network. Firstly, the original bearing vibration signal is decomposed by VMD into a series of modal components containing fault characteristics. Secondly, the instantaneous frequency mean value method is used to determine the number of local modal components. And the two-dimensional feature matrix is composed of determined local feature components and the original data, which is the input of the CNN. Thirdly, the CNN is used to implicitly and adaptively extract the fault feature and its output is the input of LSTM layer. And the LSTM is used to extract time series information of fault signals. Finally, the output layer is used to realize the pattern recognition of multiple faults of the bearing using Softmax function. The experimental results show that the proposed method improves the accuracy of the diagnosis and overcome the shortcomings of the traditional diagnosis methods.

Keywords: Bearing Fault Diagnosis, Variational Modal Decomposition (VMD), Convolutional Neural Network (CNN), Recurrent Neural Network, Timing Sequence.

P1110

Human Action Recognition Based on State Detection in Low-resolution Infrared Video

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This paper proposes a recognition method of human action based on the states in infrared image frames of thermopile array sensors. Two sensors are used for the top-side deployment. Each frame data collected by the thermopile array sensor is called infrared heat map with a resolution 24 × 32. It is sequentially processed by the quantification, time-domain filtering and background removal operations. Then those processed data are used for the training of state detection models. The state detection models detect the state of the human target in each of frame, and the state sequence is obtained. Finally, A semantic analysis method functions on the state sequence and converts it into the corresponding action. The experimental results have shown that the proposed method can recognize human actions correctly.

Keywords: Human Action Recognition, Semantic Analysis, Infrared Heat Map, Thermopile Array Sensor.

Session	SS13 Intelligent Computing and Pattern Recognition (2)
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P1237

Gestures recognition of sEMG signal based on Random Forest

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The surface electromyographic (sEMG) signal is a bioelectric signal generated by muscle activity collected from the human epidermis, which contains rich information about muscle activity, and the EMG signal caused by different movements is different, which can reflect the different movement states of human limbs. Therefore, by collecting, processing and feature extraction of sEMG signals, it can realize the recognition of human hand movements, and can be used as the control source of the prosthesis to realize the control of the prosthesis. In this paper, we propose a Random Forest algorithm-based model for sEMG signal processing and human hand movement recognition, and design an EMG signal conditioning circuit for the acquisition and conditioning of sEMG signals of arm muscles, and store the data using a NI data acquisition card. At the same time, the random forest model is trained using the public dataset to realize the classification of four kinds of actions: Fist clenching, Hand opening, Wrist internal rotation and Wrist external rotation, which provides a new method and idea for hand gesture action recognition and also facilitates further research work in the follow-up.

Keywords: sEMG Signal, Signal Conditioning, Feature Extraction, Random Forest, Action Recognition.

P1254

Prediction of Lower Limb Action Intention Based on Surface EMG Signal

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Aiming at the problem of helping lower limb disabled people recover their ability, this paper classifies and recognizes four kinds of movements (sitting, thigh lifting, leg lifting and leg straightening) based on surface electromyography (sEMG). Firstly, the healthy subjects were trained by collecting the surface EMG signal data of multiple groups of lower limbs. The EMG sensors were placed in the rectus femoris, medial femoris, semitendinosus and gastrocnemius to collect data. The noise is filtered by Butterworth filter and EMD signal reconstruction method, and the pure signal is obtained. The EMG features of each channel data are extracted, and the normalized input vector is sent to the classifier. In this paper, traditional classifiers such as random forest, xgboost and linear discriminant analysis are used to classify lower limb movements. Then, the accuracy of various classifiers is compared. It is found that the recognition accuracy of machine learning is higher, and EMD signal reconstruction method is better than Butterworth filter in the pretreatment of EMG signals, LDA classification accuracy is the highest, which can reach 100%. At the same time, the prediction speed of machine learning is faster, which can reach 300ms.

Keywords: sEMG, Feature Extraction, Machine Learning, Deep Learning, Empirical Mode Decomposition.

P1284

Radar Emitter Identification Based on Co-clustering and Transfer Learning

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In recent years, artificial intelligence and machine learning have been used to identify radar emitters. However, there are two basic assumptions in traditional machine learning: (1) the data of training set and test set are independent and identically distributed. (2) only a large number of labeled data can train a classification model which can effectively classify test set data. In other words, without enough training samples, it is impossible to learn a classifier that performs well in new radar emitters. In transfer learning, the existing radar data from related fields can help to learn such a classifier, which is called knowledge transfer. This can be achieved by eliminating the distribution difference between the original data and new radar emitter data. Therefore, we choose a new domain adaptation method called Manifold Embedding Distribution Alignment (MEDA) to solve the above challenges. MEDA firstly maps the data to Grassmann manifold, and dynamically aligns marginal distribution and conditional distribution in this space. Finally, based on the mapped data, a domain invariant classifier is obtained. Yet, this method is sensitive to the differences between data. If the similarity between data is too low, the knowledge learned from the original data will have a negative impact on the identification of new data. Thus, we introduce the co-clustering algorithm to discover the partial "instance-feature" structure over both instances and features. Simultaneously, considering the related knowledge of "instance-feature" and related new instances, the original data can be reconstructed. The reconstructed original data can be more relevant with the new radar emitter data. Empirical results demonstrate the effectiveness of our method.

Keywords: Transfer Learning, Domain Adaption, Distribution Alignment, Co-Clustering.

P1327

Transformer-Based End-to-End Scene Text Recognition

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In recent years, regular scene text recognition has made great progress, but irregular text recognition still has certain difficulties. Most current text recognition methods treat text detection and text recognition as two separate tasks.In order to better recognize irregular text, this paper proposes an end-to-end scene text recognition based on a Transformer model, which not only uses the attention mechanism to perform Decode,but also introduce a network for correcting pictures and a network structure that expands its model through a bidirectional decoder. In order to better evaluate the performance of this model, experiments are carried out on data sets such as SVT and ICDAR 2013. The experiments prove that the method in this paper relatively balances complexity and accuracy, and has obvious performance advantages.

Keywords: Scene Text Recognition end to end Transformer Irregular Text Recognition.

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P1208

Prediction of Air Conditioning Energy Consumption Based on BP Neural Networks with an Each-Column Optimization Synthesis Algorithm

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Smart city construction is closely related to building energy consumption data analysis, and energy consumption prediction is helpful to guide urban power dispatching strategy. In general, the artificial neural network models used for energy consumption prediction are often based on the optimization of a single network,

which has some short comings such as poor generalization ability and unstable fitting accuracy. Therefore, in order to improve the performance of BP neural network in building air conditioning energy consumption prediction, a per-column optimization prediction model is constructed in this paper. In order to avoid falling into the local minimum, genetic algorithm and particle swarm optimization algorithm are introduced to optimize the weight and threshold of the basic BP neural network to avoid the randomness of the parameters. Then, in order to improve the reliability and prediction accuracy of the model, the optimal prediction value is identified on the basis of the BP model prediction value based on the optimization algorithm. In addition, this paper makes an experimental study on the real air-conditioning energy consumption of a building in Laixi City, and the experimental results show the superiority of the model. The prediction accuracy is improved by about 79%, and the reliability of the algorithm is also improved. In the long run, the model can provide advance prediction for urban power dispatching and contribute to the construction of smart cities.

Keywords: BP Neural Network, GA, PSO, Energy Consumption Prediction.

P1304

Fault Detection and Isolation for Chiller System based on Deep Autoencoder

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In practical chiller systems, applying efficient fault diagnosis and Isolation (FDI) techniques can significantly reduce the energy consumption and keep the environment comfortable. The success of the existing methods for fault detection and diagnosis of chillers relies on the condition that sufficient labeled data are available for training. Generally, the number of labeled data is limited while abundant unlabeled normal data are available. To make effective use of the large number of unlabeled data to improve the fault detection (FD) performance and realize fault isolation (FI), a novel data driven FDI method based on the deep autoencoder (DAEFDI) is proposed. Specifically, DAEFDI method consists of two parts: fault detection (DAEFD) and fault isolation (DAEFI).

For the DAEFD part, the unlabeled normal data is used to learn a DAE model to describe the chiller system. When the reconstruction error is higher than the threshold, it is considered that the system deviates from the normal state. For the DAEFI part, when it is detected that the system is in a fault state, the source variable caused the fault is found according to their proportion in the reconstruction error. Experimental results demonstrate the effectiveness of the DAEFDI method.

Keywords: Fault detection, Isolation, Deep learning, Autoencoder, Chiller System.

P1107

Optimization of A Boil-Off-Gas Reliquefaction System for Small-Scale Liquefied Natural Gas Fueling Stations

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Boil-off-gas (BOG) yielded in a liquefied natural gas (LNG) fueling station should be recovered to protect the environment and improve its economic performance. A BOG reliquefaction process based on the single-stage mixed refrigerant cycle (SMR) is designed for LNG fueling stations. The thermodynamic performances of the process are analyzed based on the simulation in Aspen HYSYS, and the single and multi-objective optimization of the system is conducted using genetic algorithm (GA) and non-dominated sorting genetic algorithm-II (NSGA-II) respectively. By single-objective optimizing method, the energy consumption is reduced by 11.9%, and the system exergy efficiency is increased to 38.8% comparing with the base case. Then, a series of Pareto-optimal parameters are obtained by the multi-objective optimization, and optimal of the proposed system can be determined achieving low energy consumption and relatively high heat transfer efficiency. The results indicated the NSGA-II based multi-objective optimization could be a useful method for the BOG reliquefaction process designing.

Keywords: Liquefied natural gas, Boil-off-gas, Reliquefaction, Optimization.

P1108

Removal of R134a from air/R134a Mixture Based on Cryogenic Condensation Method

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The emission of greenhouse gases is aggravating the global warming. Nowadays, R134a is widely used in refrigeration engineering, and its globe warming potential (GWP) is relatively high (1301). So, it is imperative to recover the R134a in refrigerating devices, and prevent it from being released to the atmosphere. In present study, the R134a/nitrogen mixture is cooled by cryogenic nitrogen and R134a is removed and captured based on the different boiling point of the mixture. The self-programming approach was adopted to calculate the heat and mass transfer process of the mixture in different molar concentration in a sleeve-type heat exchanger with recuperating. The results of the calculation shown that, the required length of the heat exchanger is different under various molar concentrations. The temperature distribution of the mixture gas, the wall temperatures of the heat exchanger and the cold nitrogen, as well as the molarity and the accumulation of R134a at different length are also computed and plotted into graphs. From the obtained data, it could be found that the molar concentration of R134a in the mixture could be reduced to 100ppm which is low enough to discharge. This work could be referenced by further studies and engineering applications.

Keywords: Condensation, Removal, R134a, Sleeve-Type Heat Exchanger.

P1181

A Multi-Objective Optimization Of Energy Consumption and Thermal Comfort for Active Chilled Beam Systems

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This study considered the trade-off between energy consumption and thermal comfort as a multi-objective optimization problem and proposed a novel and practical solution by utilizing empirical energy models of the ACB system and an evolutional non-dominated sorting genetic algorithm II. Chilled water flow rate, primary airflow rate, and room temperature in ACB systems are specifically chosen as control variables due to the control convenience. Besides, a parameterless selection strategy that considers both thermal comfort and energy consumption is proposed to select the most appropriate solution among Pareto optimal solutions. Three steady-state experiments with different heat load conditions are conducted. Compared to experienced operation, the proposed strategy demonstrates a maximum of 39.32% of energy saving and 12.21% of PPD reduction by increasing the water flow rate and room temperature, and reducing the primary airflow rate.

Keywords: Active Chilled Beam, Energy Conservation, Thermal Comfort, Multi-Objective Optimization, NSGA-II

P1194

A Hybrid ANN-LSTM Based Model for Indoor Temperature Prediction

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To achieve the better control of heating, ventilation and air conditioning (HVAC) with the energy saving target, the accurate indoor temperature prediction plays a fundamental role However, existing temperature prediction approaches genera overlook the relations with other enviromental variables, which results in unsatisfactory prediction results. Considering this de feet, this paper developed a novel hybrid artificial neural networl (ANN) and long short term memory (LSTM) model (HAL) to predict indoor multiple step ahead temperature. The proposed HAL can model the temperature pattern by LSTM and lean the relations with relative humidity and other related variables by ANN simultaneously. To avoid the error propagation, we make a direct map between the input feature and the predicted temprature. The proposed HAL is implemented on a real' world indoor environmental dataset and extensive experiments assessments are conducted. The results show that the proposed HAL outperforms LSTM, MLP and other data driven methods with strong robustness.

Keywords: LSTM, ANN, Hybrid model, Temperature pre diction, HVAC.

P1236

Optimization of Solar Collector and Heat Storage Tank for Solar Absorption Refrigeration

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Taking the solar hot water circulation process in absorption refrigeration as the research object, two temperature control strategies are proposed according to the operating temperature range of working pairs in the generator, and the model of solar hot water circulation is built. The tilt and azimuth of solar collector are optimized according to the maximum radiation amount per unit area of collector with Hooke-Jeeves algorithm. The area of collector is optimized according to the solar fraction specification value with 0.5. The volume of the heat storage tank is optimized according to the maximum solar fraction and minimum start stop times of generator circulating pump. The optimization method proposed can guide the design of solar hot water circulation system for solar absorption refrigeration.

Keywords: Hot Water Circulation, Temperature Control Strategy, Case Optimization, Solar Collector, Heat Storage Tank.

Session	SS15 Model predictive control for power converters
Date	1 – 14 August 2021

P1008

Tolerant Sequential Model Predictive Voltage Control for the Neutral-Point Clamped Three-Level Three-Phase Inverters

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A simple strategy called tolerant sequential model predictive voltage control (TSMPVC) for the netural-point clamped three-level three-phase inverters is proposed. Different from the traditional model predictive control, the double-hierarchy cost function is used in this strategy. Becasuse of this, the adjustment of weighting factors is avoided and the candidate voltage vectors can be dynamically selected according to the preset tolerance. Finally, the simulation results are given to validate good performance of this strategy.

Keywords: Clamped Three-Level Three-Phase Inverters, Model Predictive Control, Double-Hierachy Cost Function, Tolerance, TSMPVC.

P1017

Current-sensorless Finite-Control-Set Model Predictive Control for Three-level Voltage Source Inverter

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The paper proposes a current-sensorless finite-control-set model predictive control (FCS-MPC) method for three-level voltage source inverter (3L-VSI). Firstly, based on the proposed control model, the predictive variables of traditional FCS-MPC method are converted into capacitor voltage and current. Then, in order to eliminate current sensor completely, a capacitor current observer is utilized to estimate the capacitor current, which could reduce system cost and enhance reliability. Besides, the estimated current is brought into the prediction formula, and the optimal voltage vector is selected by minimizing cost function and applied to the control of 3L-VSI. Finally, simulation comparison results of traditional and current-sensorless FCS-MPC demonstrate the effectiveness of the proposed control scheme.

Keywords: Three-Level, Voltage Source Inverter, Current-sensorless, Finite-Control-Set Model Predictive Control.

P1117

Multi-stage Series Model Predictive Torque Control for SPMSM Drives

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A multi-stage series model predictive torque control suitable for permanent magnet synchronous motors is proposed in this paper. Compared with the conventional MPTC, the weighting factor is eliminated and the switching frequency is reduced while the steady-state control performance is guaranteed. Firstly, the instantaneous power theory is introduced. The control of torque and flux linkage is transformed into double torque control of active torque and reactive torque by using the idea of instantaneous active power and reactive power. Then, the predicted value of double torque in the next m moments is predicted by iterative operation (m-stage series method), and the cost function is formed by comparing with the extrapolated reference value stage by stage, the optimal voltage vector is selected gradually through the m cost functions and applied to the converter. Finally, the effectiveness of the method is verified by experiments. The proposed method not only guarantees the steady-state control performance, but effectively also reduces the switching frequency.

Keywords: PMSM, Multi-Stage, Series Model Predictive Control, Switching Frequency.

Session	SS16 Modelling and Control of Space Precision Systems
Date	1 – 14 August 2021

P1088

A Fuzzy PI Controller for Piezoelectric Fast Mirror Based on Particle Swarm Optimization

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In this paper, the hysteresis model and electric-mechanical dynamic model in series are presented to model the complex dynamic behavior of piezoelectric fast steering mirror. To realize its precise control, a compound controller is designed by combining the feedforward control based on Bouc-Wen inverse model and fuzzy PI control. Then, the parameters of fuzzy PI are adjusted by particle swarm optimization algorithm. Finally, the simulation and experimental results verify the effectiveness of the proposed control method compared with the conventional PI control.

Keywords: Piezoelectric Fast Steering Mirror, Hysteresis, Fuzzy PI, Particle Swarm Algorithm.

P1125

Surface Control of Large Deployable Membrane Diffraction Antenna

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Large deployable membrane diffraction antenna plays a significant role in achieving high-precision remote sensing detection in the future owing to its super large aperture. In order to accurately adjust and maintain the primary mirror surface of the deployable diffraction antenna, a novel scheme of surface shape control has been proposed in this paper. In the scheme, the large deployable antenna is divided into several mirror units and each mirror unit is spread by braced frames. Besides, the membrane mounting units are controlled by six actuators with 6 degrees of freedom. The actuators which are low cost and applicable in complex environment are developed according to relevant control requirements. The designed actuators have the advantages of wide adjustable range (up to 21mm) and high precision (better than 0.16μm), which is much better than the traditional piezoelectric actuator scheme, and the cost performance is higher than the adjustment scheme of optical telescope. Finally, the simulation results demonstrate the feasibility of the proposed control scheme. The performances of the actuators are displayed by experimental tests.

Keywords: Large Deployable Antenna, Large Range and High Precision Actuator, Surface Control.

P1189

Development of Ultra-quiet Gravity Unloading for Micro-vibration Testing of Space Precision Payloads

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To ensure the performance and reliability of ultra-quiet payloads in orbit, the ground test are usually carried out before launch. However, the gravity unloading system with suspension introduces redundant disturbances into ultra-quiet payloads.

The gravity unloading system may affect the vibration isolation performance of the ultra-quiet payloads. To solve the problem of introducing disturbances, a gravity unloading system with high stiffness shelf and ultra-low frequency spring is designed in this paper. Testing results show that the gravity unloading system reduce the redundant disturbances to less than 2μg within the frequency range of 0.6-100Hz, which can simultaneously guarantee the gravity unloading function and ultra-quiet environment.

Keywords: Micro-Vibration, Suspension, Ultra-Quiet Payloads.

P1089

Acquisition, Scanning and Control Technology for Inter-satellite Laser Communication

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Due to the complex space environment, it is very difficult to establish communication links between satellites efficiently and quickly. Considering laser power limitation and environmental conditions, the gazing/scanning method is selected to achieve inter-satellite laser communication. Firstly, this paper establishes the theoretical model of the field of uncertainty (FOU) and analyzes the capture probability. In order to scan the entire FOU, the scanning step model and the spiral scanning paths are studied. Then, the model of the gimbal mirror is established and different types of scanning paths are selected for scanning simulation. Finally, the active disturbance rejection control (ADRC) and proportional integral (PI) control are designed for the gimbal mirror, respectively. The simulation results validate that the control performance of ADRC is better than PI controller.

Keywords: Communication links, Acquisition, Spiral scanning, ADRC.

Session	SS17 Future Robotics
Date	1 – 14 August 2021

P1213

Intent Prediction of Pedestrians via Integration of Facial Expression and Human 2D Skeleton for Autonomous Car-like Mobile Robots

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Autonomous car-like mobile robots such as delivery robots have now become a hot research topic in the field of robotics. Accurate prediction crossing intention of pedestrians is important to improve robot delivery efficiency and protect pedestrian safety. However, most current algorithms only consider the features of the key points of human skeleton, and the prediction effectiveness needs to be improved. In this paper, we proposed an algorithm that can predict the intent prediction of pedestrians via integration of facial expression and human 2D skeleton for autonomous car-like mobile robots. Firstly, we collected videos of pedestrians passing on the road as dataset. Then we extracted the key points of the human skeleton and facial expression of pedestrians at different moments based on the videos, and then combined them to build a dataset for predicting pedestrian intention to pass. We constructed a neural network by integrating Graph Convolutional Network (GCN) and Long Short-Term Memory (LSTM), and trained and validated it with the dataset. The network can extract more detailed spatial features and timing features than the traditional method only based on LSTM. The presented method is experimentally proven to obtain an accuracy rate close to 80% with only 200 sets of data.

Keywords: Intent prediction of pedestrians, Facial expression, Human 2D skeleton, Autonomous car-like mobile robots.

P1239

Multi-scale Extreme Exposure Images Fusion Based on Deep Learning

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Existing multi-exposure fusion focus on fusing more than two images differently exposed.

However, when there are only two images with extreme exposures (large exposure and low exposure), it is difficult to prevent relative brightness reversal from happening in the fused image. In this paper, we introduce a simple deep learning architecture for fusion of two images with extreme exposures. To obtain preferable features, the proposed algorithm considers both low and high resolution in the two input images with extreme exposures. Particularly, the two inputs are firstly decomposed to different Multi-scale layers using downsampling and convolutional neural network. The images are fused in different layers, and then the fused image is obtained by reconstructing using up-sampling and convolutional neural network. The quantitative and qualitative analysis of the experimental results show that the proposed algorithm outperforms existing multi-scale exposure fusion algorithms in the sense that it retains the natural brightness and improves the MEF-SSIM.

Keywords: Exposure Fusion, Pyramid Structure, Deep Learning, Multi-Scale.

P1296

Global Path Planning for Fire-Fighting Robot Based on Advanced Bi-RRT Algorithm

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Successful and efficient path planning is essential for autonomous mobile robot. Traditional Rapidly-Exploring Random Tree(RRT) algorithm usually suffer from long path planning time and strong randomness in specific environment such as depression trap and narrow channel. In order to tackle such problem, in this paper a bidirectional fast search algorithm based on violent matching and regression analysis is proposed for fire-fighting robot. Specifically, by using violent matching strategy, the path can be searched directly when there are few obstacles. In addition, the regression analysis reduces the probability of sampling nodes appearing in the same area. Meanwhile, a bidirectional RRT algorithm is employed to improve the path search efficiency. Finally, the redundant nodes in the random tree are discarded by the method of node backtracking, which reduces the robot control complexity. Several comparison experiment case studies are carried out on Rviz, and the results validate the effectiveness and advantages of our proposed approach.

Keywords: Violent Matching, Bidirectional Fast Extended Random Tree, Path Planning, Regression Analysis, Node Backtracking.

P1292

Vision-Based Formation Control for a Heterogeneous Multi-Robot System

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This work presents a decentralized formation control approach for a heterogeneous multi-robot system including a team of nonholonomic unmanned ground vehicles and an unmanned aerial vehicle based on visual localization. Relying only on the visual information from the onboard camera mounted on the unmanned aerial vehicle, the unmanned ground vehicle team can be controlled in a desired formation with the flying drone. A gradient-based control law is designed, in which the formation producing, collision avoidance and field of view constraint have been considered comprehensively. Finally, the performance and validness of the developed method are verified through simulations.

Keywords: Heterogeneous Multi-Robot System, Visual Localization, Formation, Field of View Constraint, Gradient-Based Method.

P1461

Model and Data Driven Pseudo-HDR Imaging

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It is an ill-posed problem to restore a high dynamicrange (HDR) image from one low dynamic range (LDR) image.Instead of using conventional reverse tone mapping to restore theHDR image, two differently exposed LDR images are generatedfrom the underlying LDR image by fusing model-driven anddata-driven approaches. One is brighter than the input imageand the other is darker than the input image. The three imagesare fused together via a multi-scale exposure fusion algorithm toproduce a desired HDR image which can be displayed directlyby existing LDR digital devices. The proposed algorithm canbe embedded in smart phones or digital cameras to produce apseudo-HDR image.

Keywords: HDR Image, Model-Driven, Data-Driven, Multi-Scale Exposure Fusion.

Session	SS18 State Monitoring and Prediction
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P1133

Simulation Analysis of Inconsistency of Series-connected Batteries under Constant Current Condition

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Lithium battery (LiB) is widely used in electric vehicles (EVs), energy storage power stations and other fields .because of its high voltage, light weight, high energy density, good cycle performance, low self discharge rate and no memory effect, less environmental pollution and other significant advantages. However, due to the limited voltage and capacity of battery cells, battery is usually used as a battery pack composed of hundreds of single cells in parallel or series, The difference between batteries not only affect the charging and discharging capacity of batteries, but also lead to battery aging and potential safety problems. It is of great significance to study the influence of the differences between cells on the battery pack for battery grouping and battery balancing. This paper takes the coupling relationship among the initial state of charge (SOC), initial capacity and initial internal resistance into consideration, and establishes the relationship between the initial parameters. A model consists six cells connected in series is established based on the Rint equivalent circuit model, and simulations under different working conditions are conducted. The simulation results show that the consistency of the capacity of battery pack is mainly affected by the initial SOC and initial capacity. The influence of the two factors on capacity of battery pack consistency under different charging current rates is different. The initial internal resistance has little effect on capacity consistency under different charging current rates.

Keywords: Lithium Battery, Consistency, Battery Pack Simulation, Rint Equivalent Circuit Model.

P1162

Dynamic Performance of DAB with ModelPredictive Control Based on Double Phase Shifting

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Due to the dual active converter, the various phase shifting angles in the transmitted power are coupled to each other. The result is that as the number of phase shifting angles increases, the flexibility of its control increases considerably, but so does the complexity of the control. This paper decouples the phase shifting angles in the transmitted power, thus providing a prerequisite for the multiple phase shifting in Model Predictive Control (MPC) later on. Firstly, the phase shift angle of the transmitted power is decoupled by replacing it with a new variable. Secondly, the MPC is applied after the decoupling in order to predict the future p states. The substitution reduces the complexity of the operation and at the same time the error in the output is relatively small. Finally the correctness of the method is verified by means of simulation.

Keywords: Model Predictive Control, Decoupling, Dual Active Converters, Multi-Step Prediction.

P1206

Design of Embedded Remote Working Condition Monitoring System Based on Wireless Network Bridge

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With the development of computer network technology, remote working condition monitoring system is gradually applied to the fields of traffic and road condition, construction site, and oil well site monitoring. The traditional monitoring system can achieve its basic functions to a certain extent, but on the one hand, it does not solve the problem of simultaneous transmission of working condition data and realtime images; on the other hand, the networking is not flexible enough. Based on the embedded development board and wireless bridge communication technology, this paper constructs an embedded remote working condition monitoring system. This system combines the V4L2 (Video for linux2) programming framework provided by Linux, and transplants the collection and sending program of working condition data and image data in the development board.

First, the development board collects and packs the data; then, the data is transmitted to the upper monitoring center through the wireless bridge to realize real-time monitoring of the scene and real-time display and alarm of working condition data. This paper designs and implements an embedded remote working condition monitoring system, and builds an experimental platform to verify its feasibility.

Keywords: Embedded, Wireless Bridge, Working Condition Monitoring, Real-Time.

P1214

Design of A Fast Measuring System for Electrochemical Impedance Spectroscopy of Lithium-Ion Battery

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Electrochemical impedance spectroscopy(EIS) has many advantages such as fast, non-destructive, intuitive, and is widely used in its status and safety assessment of lithium-ion batteries. The primary prerequisite for applying impedance spectroscopy to evaluate battery status is to effectively measure the impedance spectra of lithium-ion batteries. This paper develops a set of lithium-ion battery impedance characteristics tester based on the fast Fourier transform (FFT) method. The actual test results show that the relative error of amplitude measurement is 1.5% compared with the equivalent circuit of known parameters, which proves its effectiveness. Taking a commercial electrochemical workstation as a benchmark, the average error of the modulus and phase angle of this device is 1.44% and 4.09%. In the same range of frequency, this device makes its time shorten from 5min to 52s approximately, and the cost is reduced to about 20%. The results of five consecutive measurements show that the device has good repeatability. The impedance spectroscopy measurement results of a variety of batteries with different capacities (800mAh∼100Ah) show that the device(EIS-1000) has a wide range of applications. EIS-1000 has faster measurement speed and lower cost, and provides an engineering application method for impedance spectrum measurement with a wide battery capacity range.

Keywords: Wide Capacity Range, Electrochemical Impedance Spectrum, Fast Measurement.

P1280

Adaptive Model Predictive Control with Particle Filter for Artificial Pancreas

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Controller takes an important role for artificial pancreas (AP) to regulate insulin infusion rate according variable requirements of diabetic patients. In this research, an adaptive model predictive control (MPC) algorithm is proposed to overcome the parameter uncertainty induce by inter and intra variability. Firstly, a glucose-insulin dynamic model is established to describe the integrated metabolism of glucose and insulin, in which the time-varying parameters can be extended to observable state variables. Then, particle filtering technology is introduced to track and adjust the parameters. Meanwhile, the glucose and insulin concentration in plasma (PGC and PIC) are also estimated. Finally, imbedding the dynamic model with personalized parameters, an adaptive MPC algorithm is proposed based on the estimated PIC and PGC. For validation, the insilico experiments are carried out on the 30 virtual patients of the UVa/Padova simulator. The proposed algorithm shows promising performances. It shows that the proposed method has the potential for artificial pancreas in clinical treatment.

Keywords: Artificial Pancreas, Model Predictive Control, Particle Filtering.

P1386

Review of Rotor Position and Speed Estimation Method of PMSM with Hall Sensor

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Permanent magnet synchronous motors (PMSM) are widely used in industrial control, household electrical, transportation, aerospace and other fields. The acquisition of rotor position and speed is the key to achieving high-performance control. In view of the disadvantages of the large volume and high cost of photoelectric encoders and magnetic encoders, and the limitations of sensorless control technology,

The technology of driving PMSM with low-resolution position sensor can not only control the cost but also ensure the performance of the motor. Therefore, the method of estimating rotor position and speed that can improve its control accuracy and system stability has attracted wide attention from scholars at home and abroad. The working principle of the switch-type Hall position sensor is introduced, and the source of its error is systematically summarized. Taking the method of interpolation, filter and observer as the core, this paper introduces several methods of estimating high-resolution rotor position and speed. Then this paper analyzes their principles, advantages and disadvantages, and applicable conditions. Finally, it summarizes the existing achievements and looks forward to the future development trend.

Keywords: Permanent Magnet Synchronous Motor (PMSM), Switch-Type Hall Position Sensor, Position Detection, Speed Estimation, Error Compensation.

P1118

Improvement Canny Edge Detection for the UAV Icing Monitoring of Transmission Line Icing

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Overhead power line icing disaster is one of the most noteworthy problem which highly damage the safety of power grid, so it is needed for monitoring in the area. Recently, computer vision and Unmanned Aerial Vehicle (UAV) is developing rapidly, which is suitable for the monitoring of transmission lines icing. Edge detection method is the main priority for automatically measurement of monitoring system based on UAV. There are numerous edge detection methods, but Canny edge detector is considered to be more reliable than some traditional methods. In this paper, a method of improvement Canny using hybrid technique is proposed for more accurate measurements. Traditional Canny operator and improvement Canny operator are compared and analyzed in the simulation. For the comparison the result used are mean square error (MSE), root mean square error (RMSE) and peak signal to noise ratio (PSNR). The simulation results show that the improvement Canny operator using the hybrid technique better than traditional Canny.

Keywords: Hybrid Technique, Canny Operator, Edge Detection, Mean Square Error (MSE), Root Mean Square Error (RMSE), Peak Signal to Noise Ratio (PSNR) Transmission Line Icing.

P1394

Strength Analysis for Bolted Joints Fastening the Underframe Equipment of EMU

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Bolted joints are widely applied for fasteningthe underframe equipment of the railway vehicles. The boltedjoints directly or indirectly fixed on the vehicle body bear allkinds of vibration alternating loads. Firstly, the differencesbetween Chinese and foreign relevant standards are comparedand analyzed. Taking the bolted joints fastening the batterybox hanging equipment of Electrical Multiple Unit (EMU)as an example, the overturning moment is introduced to beequivalent to the axial load of the bolt, and the strengthcalculation of the static load, fatigue load and shock load arecarried out. Finally, the alternating load measured on the lineis compared with the calculation results of fatigue strength toprove the reliability of the calculation method. Through theexploration of the strength check method for bolted joints, itprovides references for the strength design of bolted joints ofthe EMU equipment.

Keywords: Bolt Strength, Underframe Equipment, Load, Design Standard.

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P1101

Visual Management Method Applied for R&D Project Management: A Case Study

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One issue of Research and Development (R&D) project is communication timely and effectively for all participants. This issue brings, R&D project deliveries on time and on quality. This paper describes a Visual Management (VM) method in relation to the R&D project management to visualize important information between participants on R&D process chain. An effective visual management method is presented for the R&D project management with the purpose of delivering the project smoothly. This visual management method aims to visualize all necessary information for an effective communication by dealing with issues on time. The proposed visual management method is used to the case R&D project that can gather and visualize information and issues effectively, to solve daily issues on time by responsible people. With integrating the method with case R&D project, the visual management is implemented in a form of visual project office. The case study provides a detailed process that how a R&D project applies the effective visual communication method to support information transparence in project management to solve problem effectively. The paper is structured as follows: firstly, the brief literature on visual management is reviewed; secondly, the issue of information flow on R&D project are considered, and thirdly, the process of R&D visual management with its operating form - a visual management office is present and used in the case study. Finally, a discussion of the research outcomes and conclusion are summarized.

Keywords: Visual communication, Research and development management, Project management, Information transparency, Visual Management.

P1138

Robust Sliding Mode-Based Learning Control for Lane-Keeping Systems in Autonomous Vehicles

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In this paper, a robust sliding mode-based learning control (SMLC) scheme for lane-keeping systems (LKS) of road vehicles is proposed. It is assumed that all of signals in system satisfy Lipschitz-like condition, a robust sliding modebased learning controller is designed to achieve the zero-error convergence of lateral position error dynamics. A new finding is that yaw angle error dynamics is able to converge to zero asymptotically on the sliding surface. Unlike many existing sliding mode control schemes, the proposed SMLC scheme does not require the bound information of unknown system parameters. More significantly, the LKS equipped with the SMLC algorithm exhibits a strong robustness against varying road conditions and external disturbances. Simulation results demonstrate that the designed SMLC scheme could exert excellent tracking performance and robustness.

Keywords: Sliding Mode-Based Learning Control (SMLC), Lipschitz-Like Condition, Strong Robustness.

P1155

Path Optimization of Intelligent Wheelchair Based on an Improved Ant Colony Algorithm

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This paper presents an improved ant colony optimization algorithm for solving intelligent wheelchair path planning problem. The existing ant colony algorithm has many problems in solving intelligent wheelchair path planning problem, such as the extra corners of raster maps and the irregularity of corners. In this paper, the improved ant colony optimization algorithm which can effectively remove the extra corners and smooth the corners with three Bezier curves, combining the constraints of wheelchair physical conditions and environmental conditions was proposed. MATLAB software is used to verify the feasibility and effectiveness of algorithm. Meanwhile, we use the virtual reality technology provided by ROS system to establish GAZEBO physical simulation experiment platform to verify the practicability and feasibility of the algorithm in the mobile robot system. Finally, the effectiveness of the improved algorithm is verified by the movement of the mobile robot in the actual test environment. The results of the proposed algorithm are found to be satisfactory.

Keywords: Path Planning, Ant Colony Algorithm, Gazebo, Mobile Robot.

P1253

Cross Regulation Analysis of Voltage-Mode Controlled SIDO Buck LED Driver

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The voltage-mode controlled single-inductor dual-output (SIDO) Buck LED driver is studied in this paper, which has the advantages of small volume, low cost and independent dimming. The operation principle of the studied LED driver is described, and the state space average model is established. Then, cross regulation transfer functions of the dual outputs are obtained. On this basis, the cross regulation of one output to the other output of voltage-mode controlled SIDO Buck LED driver is analyzed in frequency domain. Finally, the simulation waveforms verify the theoretical analysis results.

Keywords: LED, Single-Inductor Dual-Output (SIDO), Voltage-Mode Controlled, Cross Regulation.

P1260

Modeling and Simulating of Single Autonomous Vehicle Under Urban Conventional Traffic Flow

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In recent years, with the gradual development of artificial intelligence, as one of the important branch applications, intelligent transportation is also developing rapidly, and the research of autonomous vehicles has also attracted more and more attention. With the increase in vehicle ownership and the increase in road congestion, the improvement of transportation efficiency has always been an urgent problem. With the development of autonomous vehicles, the impact of the application of autonomous vehicles on travel efficiency has become an important research subject. This article uses sumo to build an urban road network to simulate real road scenes, and to study the impact of autonomous vehicles on traffic flow by controlling the operating parameters of autonomous vehicles in the traffic flow.

Keywords: Automated Vehicle, Mixed-Automated Traffic, SUMO.

P1289

On the Combination of PID control and Reinforcement Learning: A Case Study with Water Tank System

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Reinforcement learning (RL) has attracted great interest from researchers in recent years. RL performs as human or better in many fields such as games and robot control. Although this technology is booming in computer science, it has not been practically applied in industrial process control. Up to now, proportionalintegralderivative (PID) control is still the most dominating and popular control method in industrial control. In this paper, we propose a combination of deep reinforcement learning (DRL) and PID control for better process control performance. The idea is generated by the following observations: for PID controller,

its transient performance is not usually well enough to meet a strict requirement or in complex signal tracking tasks; For RL technology, a perfectly designed reward function is required for training. However, in practice, the reward function needs to be tested through trial and error, which will lead to a waste of computational power and time. By combining these two strategies, PID controller can help to improve the steady-state performance of RL control by its integral term, while the trained RL agent is able to improve the transient performance of PID controller. Several case studies with the water tank system are presented to demonstrate the effectiveness of the combined PID + RL control strategy.

Keywords: PID, Reinforcement Learning, Water Tank System.

P1319

Dynamic State Estimation of Smart Grid Based on CKF under False Data Injection Attacks

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The accurately estimated state is of great importance to a stable running condition of smart grid. The emergence of cyber attacks brings new challenges to the state estimation of smart grid. Especially, false data injection (FDI) attacks deteriorate the accuracy of state estimation by injecting the false data into the measurement device. To solve the problem, a cubature Kalman filter (CKF) is proposed, which can estimate the dynamic state of smart grid under FDI attacks. Firstly, due to the complexity of the state equation of smart grid, this paper adopts Holt's two-parameter exponential smoothing method to establish the state equation. Secondly, according to the principle that the measurement residuals before and after the FDI attack are equal, the expressions of the attack vectors are established. And they are applied to the measurement quantities to avoid the conventional bad data detection. Then, the cubature Kalman filter algorithm is utilized to estimate the dynamic state of the smart grid attacked by FDI. Finally, the simulated results verify effectiveness of the proposed method.

Keywords: Smart Grid, Dynamic State Estimation, FDI Attacks, CKF.

P1320

Day-Ahead Economic Dispatch of Integrated Energy System Including Power to Gas

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The power-to-gas (P2G) technology can convert electric energy into natural gas, which provides a new solution for the integrated energy system to absorb clean energy. In this paper, a day-ahead economic dispatch model is proposed for electricity-gas integrated energy system considering P2G. The objective function of economic dispatch is constructed to be compatible with four parts, i.e., the cost of electricity purchased, the cost of gas purchased, the cost of wind power and P2G device operation. The power balance of system, interaction power range with external grid, rated power of P2G device, etc. are taken as the constraints of economic dispatch. CPLEX based on MATLAB's Yalmip toolbox is used to solve the economic dispatch problem. Finally, two study cases are conducted to verify that the total cost of day-ahead economic dispatch of the integrated energy system can be reduced by utilization of P2G device.

Keywords: Integrated Energy System, Power-to-Gas (P2G), Economic Dispatch.

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P1321

Distributed Fixed-Time Secondary Frequency Control of MTDC Systems

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In this paper, fixed-time distributed control of MTDC systems is presented for secondary frequency control. A fixed-time observer is constructed to estimate the synchronization error, and a fast fixed-time controller is designed to achieve fixed-time terminal frequency synchronization of each distributed generator and provide proportional active power distribution. The secondary control of each converter consists of a fixedtime consensus based frequency regulator that uses relative information from the neighboring AC areas which requires sparse communication links. Compared with the existing controllers, the proposed distributed control scheme guarantees fixed-time convergence of the synchronization error, independent of the initial conditions, allowing the stabilization time to be predesigned offline according to the requirements in MTDC systems. In addition, the stability of the method is verified by Lyapunov function. Simulation results validate the effectiveness of the proposed control scheme.

Keywords: MTDC System, Fixed-Time Control, Frequency Restoration, Active Power Sharing.

P1360

Robust H_∞ Cruise Control of High-Speed Train with Parameter Uncertainties, Time-varying Delays and Disturbance

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A novel robust H_∞ control methodology for high-speed train (HST) with the target of high-precision velocity tracking and operation safety is studied in this paper. The dynamic equation of HST is established based on a multi-particle cascade model connected by flexible couplers, where the delays caused by transmission process, and uncertainties of train mass, stiffness of couplers and aerodynamic drag are considered. The stochastic errors of the line data are defined as operational disturbances. The controller is designed based on Lyapunov theory and linear matrix inequalities (LMIs), under which situation the train track the reference speed trajectory, the relative displacement of couplers is stable at equilibrium state as well as satisfy the prescribed H_∞ performance index. Comparative experiments are carried out to demonstrate the effectiveness and robustness of the controller.

Keywords: Robust H_∞ Control, High-Speed Train, Velocity Tracking, Time-Varying Delay, Linear Matrix Inequality.

P1402

Navigation Stack for the Crawler Robot Servosila Engineer

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Navigation is one of the most critical problems in all areas of mobile robotics, including urban search and rescue robotics. Autonomous navigation tasks appear almost in every robotic project. A preliminary validation on a new navigation algorithm could be efficiently performed within a simulator, which allows constructing any type of an environment and simulate different operational conditions for a robot. Therefore a development of an appropriate simulated robot model and its navigation capabilities within a simulator are recently in a focus of many research teams. This article presents a number of improvements to the Gazebo simulator model of the crawler robot Servosila Engineer and a newly developed navigation stack. The navigation stack was validated with the robot's model in the Gazebo and with a real robot in a laboratory environmen.

Keywords: Crawler Robot, Servosila Engineer, USAR, Urban search and Rescue, 3D Model, Navigation, Gazebo, ROS.

P1407

Mobile Application for Controlling Multiple Robots

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Smartphones are becoming more and more high-performance devices every year, which allows to use them in new types of applications, including control and automation. This paper presents an Android OS based control tool that unifies a remote control of heterogeneous robotic systems. The current version of the tool controls the humanoid ROBOTIS OP2 robot, the wheeled differential drive TIAGo Base mobile robot, and the crawler Servosila Engineer mobile robot. Communication between a mobile device and the robots employs the RosJava library and the TCP/IP network protocol stack. The controls were implemented for compound kinematic systems with 3D robots' models displaying. Sensory data visualization and robots' movements controls were added to the application.

Keywords: Android OS, GUI, ROBOTIS OP2, TIAGo Base, Servosila Engineer.

P1423

Two-time-scale Containment Control of Multi-agent Systems with State-dependent Switching Topology

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This paper proposes an event-triggered mechanism to achieve containment control for multi-agent systems with state-dependent switching topology, meanwhile ensuring a fully Zeno-free triggering for each follower. First, based on the idea of "estimation before transmission", an observer in the ϵ-time scale is designed to fast estimate the states of leaders. Second, since the communication topology is time-vary, a predefined containment control protocol is presented based on the distributed state observer, where the expected convex combination of multiple leaders is predefined by some given weights. Subsequently, the closed-loop system is transformed into a switched system and a switching approach is introduced to find a waiting time in the event-triggered mechanism. At last, we provide a practical simulation example to demonstrate the validity of the proposed mechanism.

Keywords: Event-Triggered Control, State-Dependent Switching Topology, Two-Time-Scale Controller.

P1147

Fault Diagnosis of Cascaded NPC Inverter Based on Single Sensor

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In this paper, a fault diagnosis method of cascaded NPC inverter based on single sensor is proposed. By detecting the DC side current, the specific harmonic content is extracted by Fourier decomposition as the fault feature, and the BP neural network is used for fault diagnosis. The method can install only one current sensor to identify and locate all the faults of all modules. It is important to reduce system hardware resources. Finally, the validity of the diagnostic method was verified through MATLAB/Simulink simulation and experiment.

Keywords: Cascaded NPC Inverter, Fault Diagnosis, BP Neural Network.

P1153

A Novel AC-DC Hybrid Metro Power Supply System

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This paper presents a novel AC-DC hybrid metro power supply system based on the current metro power supply system. The proposed system takes full use of the energy existing in metro power supply system, including the regenerative braking energy and renewable energy. Moreover, the AC-DC hybrid metro power supply system has high reliability and safety. In addition, this paper analyzes the energy management strategy and working modes, and then verify the effectiveness of the proposed system by simulation.

Keywords: Metro Power Supply System, Renewable Energy, Regenerative Braking, Energy Management Strategy, Working Modes.

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P1210

Control by Equilibrium

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This article considers a new approach to solution of the optimal control problem. Firstly, a stabilization system is synthesized for a control object. As a result, the control object has a stable of equilibrium point in the state space. A location of the equilibrium point depends on some vector of parameters in stabilization system. Secondly the vector of parameters, that influences on location of stable equilibrium point, is searched as a solution of the control optimal problem in the form of function of time.

Such approach allows obtained the control system with the found function of time as a program control to set in real object without changes and additional controllers. This has become possible, because the differential equation system with a stable equilibrium point is a contraction manifold. All perturbations, mistakes, and differences of the mathematical model from real object are decreased at the approximation to a stable equilibrium point. The computation example is presented, that compares two functions of time for vector of parameters, piecewise-linear and piecewise constant.

Keywords: Optimal Control, Synthesis of Control, Contraction Manyfold, Eqiulibrium Point, Symbolic Regression.

P1217

Linearization Design of Servo System and Parameter Identification Based on LuGre Model

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This paper proposes linearization control for servo systems with friction and parameter identification based on LuGre model. We give the process of controller design using state space method and analysis conditions for asymptotic stability. Considering practical application, the structure of controller is simplified. To guarantee the system stability, parameters range is derived with Louts criterion. The dynamic parameters of LuGre model are usually difficult to obtain, thus a new identification algorithm is presented by utilizing a highgain closed-loop speed control. The algorithm can conveniently get results in an acceptable precision scope. Finally, the validity of the algorithm is verified through simulation.

Keywords: Servo Systems, Lugre Model, Linearization Control, Parameter Identification, Position Tracking.

P1243

Practical Fuzzy Repetitive Control for Accurate Amplitude and Phase Tracking in Linear Compressor

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Linear compressor is a kind of novel gas pumping equipment used in refrigeration applications. Compared with conventional rotary compressor, it has the benefits of high efficiency, low noise, and less discharge pollution, which coincides with green energy strategy worldwide. As the core component in linear compressor, linear actuator provides the energy for gas pumping. Thus, its output amplitude and frequency affect system performance significantly. However, influenced by complex load of linear compressor, such as friction, gas pressure, spring elastic load, etc., the control performance of linear actuator suffers from severe amplitude decline and phase lag in high frequency tracking mode. In order to deal with this problem, a practical fuzzy repetitive controller is proposed for high frequency amplitude and phase tracking in linear compressor. Actuator modeling and controller analysis are conducted in details, and then simulation is carried out for validation. The results show that the proposed fuzzy repetitive controller works well with system and enhances working performance obviously.

Keywords: Linear Compressor, Repetitive Control, Fuzzy Control.

P1249

Lower Limb Rehabilitation Exoskeleton Control based on SSVEP-BCI

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Faced with the current increasingly serious problem of population aging and the frequent occurrence of neurological diseases. Lower limb rehabilitation exoskeleton can help patients with lower limb exercise rehabilitation. Only the subjective participation of patients in the rehabilitation process can achieve better rehabilitation results.

Therefore, this paper proposes to implement a BCI system based on SSVEP to control the exoskeleton of the lower limbs, so that the patient can actively participate in the rehabilitation process. This article uses the flickering of the pixel block on the screen to visually stimulate the patient, and classifies the EEG signal by the CCA method. The classification results are output to the lower limb rehabilitation system described in the article to realize the patient's left leg rehabilitation, right leg rehabilitation, acceleration, deceleration, and stop operations.

Keywords: SSVEP, BCI, Rehabilitation, CCA, Control, Insert.

P1252

An Adaptive Control Approach of Body Weight Support System for Lower Limb Exoskeleton Based on Trajectory Feedforward

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An adaptive control method is proposed to resist disturbance while walking with given trajectory. The method contains two parts. The optimal control method of quadratic exponent of linear system is used to avoid random interference caused by unpredicted motion. Considering that the center of gravity (COG) of user varies while walking with lower limb exoskeleton, an estimable systematic disturbance is introduced to the BWS system. And a feedforward control method based on error input is designed to avoid systematic interference. The systematic interference is modeled according to the structure of the leg in lower limb exoskeleton. The complete control approach is the combination of two controllers. Finally, simulations of different control methods have been carried out to prove the effectiveness of the proposed method.

Keywords: Body Weight Support System, Disturbance Rejection, Linear Quadratic Optimal Control, Feedforward Control, Lower Limb Exoskeleton.

P1297

An Integration Method of Heterogeneous Models for Process Scheduling Based on Deep Q-Learning Integration Agent

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By means of intelligent algorithms and cloud integration paradigm, intelligent manufacturing organizes distributed and heterogeneous resource models organically to realize the process scheduling of complex products. To this end, this paper focuses on the heterogeneous models integration problems in complex production scheduling with machine failure. Specifically, a message bus is established to integrate distributed and heterogeneous cloud resources which include process scheduling rules, meta production process and process execution facilities by uniformly described labeled proxy models. During the whole process scheduling, an virtual intelligent integration agent based on dual deep reinforcement learning is introduced to composite scheduling rules from multiple experts when successively dispatching available process to appropriate machine. Last, the integration method is tested in process scheduling. Compared with integration framework for complete models, this proposed integration paradigm which focuses on interactive models can control system complexity more efficiently. Furthermore, message simulation bus allows for asynchronous communication and log tracking. Compared with the mechanical combination of expert rules, compatible learning algorithm in this paradigm enhances the intelligence of integration.

Keywords: Heterogeneous Models, Integration Agent, Message Bus, Complex Process Scheduling.

P1302

Fuzzy Unknown Input Observer Design for Autonomous Ground Vehicles

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This paper studies the problem of vehicle state estimation. In view of the longitudinal lateral coupling dynamics and the existence of unknown inputs, a new fuzzy observer design method is proposed based on Takagi-Sugeno (TS) fuzzy control technology to realize the effective estimation of vehicle state. Aiming at the difficulty of observer synthesis of TS fuzzy system with unmeasurable antecedent variables, this paper proposes an N-TS fuzzy modeling method which can effectively avoid unmeasurable antecedent variables by using nonlinear partition method, and explores a new method of fuzzy observer synthesis of nonlinear vehicle system based on this model. This fuzzy modeling not only effectively avoids the appearance of unmeasurable antecedent variables, but also significantly reducethe real-time calculation workload of estimating vehicle variables.

Keywords: Vehicle State Estimation, Takagi-Sugeno, N-Ts, Nonlinear Partition Method.

Session	SS22 Special Invited Session (1)
Date	1 – 14 August 2021

P1103

Four-Consecutive-Samples based Frequency Estimation for Three-Phase Grids with DC-offsets

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In power grids, DC offsets can result in the frequency oscillations. So it is a challenging problem which can't be ignored in frequency estimation. To resolve this problem, this paper proposes a method called TD-FLL (time delay frequency-locked-loop) based on four-consecutive-samples (4CSs), which estimates frequency and the positive and negative-sequence components (PNSC) of the grid voltage with DC offsets in a fast and accurate way. Compared with the conventional methods, the proposed method not only has fast dynamic response but also can completely reject the DC offsets. By using the basic trigonometry and algebra, the relationship of the fundamental grid voltage, DC offsets and consecutive sample signals has been derived.

According to the relationship, a model based on basic trigonometry and algebra has been established. Based on the model, the frequency has been estimated with DC offsets suppression. Finally, the simulation results indicate that the 4CSs-model estimates the frequency accurately and has good capability of rejecting DC offset.

Keywords: Three-Phase Grids, DC Offsets, Frequency Estimation, Four-Consecutive-Samples.

P1391

Performance Comparison of DSTATCOM using SRF and IRP Control Algorithm

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In this paper, a comparative evaluation of three different control algorithms is made to derive reference currents for a three phase three wire Distribution Static Compensator (DSTATCOM). These control algorithms are synchronous reference frame (SRF) theory and instantaneous reactive power (IRP) theory including p-q and ip-iq theories of control. The effectiveness of the DSTATCOM is verified with simulation results. The simulation is carried out on MATLAB software using Simulink.

Keywords: Distribution Static Compensator, Synchronous Reference Frame (SRF) Theory, Instantaneous Reactive Power (IRP) Theory, Voltage Regulation, Harmonic Compensation.

P1119

The Mechatronic System Design of the Bed-Chair Integration System E-Bed

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With the advent of an aging society, there are more and more disabled elderly people, and the cost of care is getting higher and higher, causing a great burden to the society. In order to improve the quality of care for the disabled elderly and reduce the cost of care, this paper developed a modular and deformable multi-functional bed and chair integration system, which mainly includes a multifunctional nursing bed system, an omni-directional wheelchair system and corresponding control systems. This paper starts from the demand analysis, carries out detailed design and integrated verification and debugging for each subsystem, and develops a prototype of the integrated service robot for bed and chair E-Bed. The bed-chair integration robot system E-Bed can effectively meet the actual needs of nursing homes, reduce the labor intensity of nursing staff and improve the self-care ability of the elderly.

Keywords: Control System Design, Medical Assistive Devices, The Bed-Chair Integration.

P1131

Analysis of the Movement Mechanism of the In-oil Storage Tank Floor Inspection Robot

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The robotic technology of in-oil tank inspection has irreplaceable advantages and broad application prospects. Based on the in-oil storage tank floor inspection task, we analyze the movement mechanism of wheel type and crawler type robot motion modes. We obtain guiding formulas that enable the two kinds of tank floor inspection robots to achieve stable motion and bring in the design parameters for theoretical calculations. Finally, we verify the correctness of the theoretical derivation results through virtual simulation. The movement mechanism analysis method proposed in this paper will provide theoretical guidance for the design of the in-oil storage tank floor inspection robot.

Keywords: Storage Tank, In-Oil Inspection Robot, Movement Mechanism.

P1222

Research on Track/Hold Circuit Based on Feedback Compensation

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This article mainly starts from improving the accuracy and speed of AC measurement, and conducts simulation research on the tracking/holding circuit. According to the switching characteristics of the switch tube, a track/hold circuit model is constructed. Based on this model, the error source and linearity performance are analyzed, and the track and hold circuit is improved. Finally, a track-and-hold circuit based on feedback compensation is designed to achieve a better match between accuracy and speed, and the simulation results of the two circuits are compared to verify that the circuit can accurately implement the sample-and-hold function.

Keywords: Track/ Hold, Accuracy, Feedback, Pedestal error.

P1241

UCB-ENAS based on Reinforcement Learning

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Deep learning has achieved good results in many practical applications, but the network architecture is largely dependent on manual design. In order to liberate the network architecture from manual design, the Neural Architecture Search (NAS) came into being. NAS is mainly divided into three parts: search space, search strategy and performance estimation strategy. Because of the huge search space of NAS, search process becomes extremely long. A good search strategy can search out the high-performance network architecture in a short time. In this paper, we study the search strategy for NAS problems and propose the UCB-ENAS algorithm based on reinforcement learning, which significantly improves search efficiency in a flexible manner. NAS problem can be regarded as a stateless Multi-armed Bandit problem, so we use long short-term memory (LSTM) and Upper Confidence Bounds (UCB) to jointly build a controller that generates a network architecture, and then use the policy-based REINFORCE algorithm to update the controller parameters to maximize the expected reward. Controller parameters and model parameters are alternately optimized. A large number of experiments show that the proposed algorithm can quickly and efficiently search the network architecture, which is faster than ENAS in search speed, and the performance is higher than the architecture searched by DARTS (first order). For example: 56.54% perplexity is obtained on the PTB dataset.

Keywords: Deep Learning, Neural Architecture Search, Reinforcement Learning, Long Short-Term Memory, Upper Confidence Bounds.

Session	SS23 Special Invited Session (2)
Date	1 – 14 August 2021

P1245

A Fault Diagnosis Framework for Aircraft Electromechanical System

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With the rapid development of the aviation industry and the continuous improvement of aircraft airworthiness requirements, how to accurately and efficiently analyze and troubleshoot aircraft failures is an urgent issue for the aviation industry. Both the aircraft structure and the system are relatively complex, and it takes a lot of time, manpower and material resources to analyze and repair aircraft failures while meeting airworthiness requirements. Therefore, this paper designs an aircraft electromechanical system fault diagnosis framework, and develops an online, real-time fault diagnosis expert system program for electromechanical system design. The effectiveness of the program is validated on a PowerPC computer and VxWorks operating system. The storage and time consumptions satisfy the requirement of real aircraft applications.

Keywords: Aircraft Fault Analysis, Online And Real Time Fault Diagnosis, Expert System.

P1250

Control Strategy of Rope Driven Upper Exoskeleton Robot Based on Screw Method

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With the advance of the deep aging process of society, the spread of upper limb motor dysfunction has become a serious social problem, and the development of excellent performance of upper limb rehabilitation robot has become a major social demand of the country. This thesis will take the 7-DOF rope driven upper exoskeleton rehabilitation robot as the research object. According to the mechanical structure of the 7-DOF upper exoskeleton prototype, the kinematics and dynamics model were established, the feasible motion space of the upper exoskeleton was obtained, and the relationship between the joint pose and the rope length, and the joint moment and the tension on the rope was calculated. According to the actual needs, the closed-loop position control and force control frame of the motor are built.The upper limb exoskeleton robot is controlled based on the spin method.

Keywords: Upper Limb Rehabilitation Robots, Cable-Drive, Dynamics, Kinematics, Screw

P1255

Design and Stiffness Analysis of a Cable-Driven Continuum Manipulator

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Compared with traditional rigid link manipulators, cable-driven continuum manipulators have many advantages, such as lightweight mechanical structure, large reachable workspace, high dexterity, and high maneuverability. It is especially suitable to the applications requiring high maneuverability over complex and confined spaces. In this paper, the end stiffness of a cable driven continuum manipulator is modeled and its influencing factors are analyzed. The flexible backbone is used as the support of the manipulator, and the deformation of the flexible support skeleton is precisely controlled by the piecewise drive scheme. Through the analysis, it can be seen that the main factor affecting the stiffness of the manipulator is the joint variable of the module, so we get two kinds of stiffness control schemes for the manipulator.

Keywords: Stiffness Analysis, Cable-Drive Device, Continuum Robot, Manipulator.

P1259

A Comparative Study of Different Models in Ancient Poetry Translation

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Ancient poetry is an important part of Chinese culture. There have been projects like Jiuge to combine ancient poetry with deep learning. The language of ancient poetry is often refined, and it needs rich imagination to understand its meaning. As a result, it is difficult to automatically implement the translation. This paper makes a preliminary attempt in this aspect, based on the data set collected by ourselves, adopts deep encoder-decoder model, such as GRU, LSTM and Transformer models, to train our model. We compare the results of the three models, which have their own advantages and disadvantages. However, due to the size of the data set and the model itself, the effect is not very ideal, and still needs to be improved.

Keywords: Deep Learning, Neural Network, Natural Language Processing, Machine Translation, Seq2seq Model, Transformer, Ancient Poetry.

P1308

Trajectory Design and Adaptive Impedance Control of Lower Limb Exoskeleton

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This paper proposes a novel human-in-loop control framework for the lower limb exoskeleton, assisting the pilot to move under different working conditions. Under the premise of ensuring the stability of the exoskeleton, the method of Zero Moment Point (ZMP) theory is used to generate the expected motion trajectory of the exoskeleton under different working conditions. In order to ensure the comfort of the pilot, an adaptive impedance controller is designed. The controller has a double closed-loop structure. The position loop realizes the exoskeleton tracking the desired trajectory, and the impedance control loop adjusts the impedance parameters to ensure the comfort of the human body. Then Lyapunov's definition was used to prove the stability of the control framework. The simulation results show that the proposed scheme can help pilots complete walking on a plane, climbing and squatting movements.

Keywords: Adaptive Impedance, Trajectory Design, Exoskeleton.

P1322

1-bit WaveNet: Compressing a Generative Neural Network in Speech Recognition with Two Binarized Methods

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With the advancement of deep convolutional neural networks, speech recognition systems achieved the amazing performance in the tasks of natural language processing field. While being outstanding, resource-constrained environments limited enterprise-level applications. In this paper, we use two binarized neural networks called Bi-real Net and PCNN (Projection Convolutional Neural Networks) to study the problem of compressing WaveNet which is a generative model in raw audio waveforms recognition. In particular, Bi-real Net and PCNN are applied to minimize the computational cost gap between real-valued and binarized WaveNet model, which leads to a new 1-bit dilated causal convolution. We collected a dataset which including over 950,000 clear key word voice without noise. In this dataset, 1-bit WaveNet were trained through these binarizations and got a satisfactory perform.

Keywords: WaveNet, Bi-real Net, PCNN, Speech Recognition, 1-bit Dilated Causal Convolution.

Session	SS24 Special Invited Session (3)
Date	1 – 14 August 2021

P1141

Research on Three-Level Bi-Directional DC-DC Converter and Its Control Strategy Used for Energy Storage System of Electric Wheeled Tramcar

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According to the working characteristics of mining 730E electric wheel tramcar which produces a lot of electric energy when it goes downhill and decelerates, an energy storage scheme is proposed. The traditional two-level DC-DC converter hat high voltage stress and large output current ripple, and the energy storage system of mining 730E electric wheel tramcar needs two-way flow of energy. In this paper, three-level Bidirectional DC-DC converter is selected as the energy storage system. Based on the analysis of the working principle of three- level Bidirectional DC-DC converter, the control strategy is studied. The simulation model is built on MATLAB I Simulink platform, and the control algorithm of three-level Bidirectional DC-DC converter is simulated and optimized. The advantages of three-level Bidirectional DC-DC converter topology are proved, and the control of bus voltage, flying capacitor voltage and battery charging and discharging current realized.

Keywords: Electric Wheel Tramcar, Three-level, DC-DC Converter, Energy Storage System.

P1156

Development of Cascade H Bridge SVG

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Recent years have witnessed a rapid development of Electrified railway. A large amount of reactive power can be generated when the electric locomotive is too much on the traction network, It Cause a serious decline in power quality, Harmonics and reactive power has negative impacts on stability and security of locomotive running. Traditional reactive power compensation technologies are difficult to meet system requirements due to the switching frequency and voltage limit. In order to overcome the contradiction between the switching frequency of power device and power capacity in the traditional SVG, the principle and topology of H-Bridge SVG were studied, Control strategy adopts Carrier phase-shifted SPWM which is applicable to Cascade H-Bridge Multi-level Converter. The SVG designed adopt the control strategy based on instantaneous reactive power voltage and two closed loop, which can quickly follow the voltage changes controlling the output of SVG. MATLAB simulation results prove the validity of the control method and the performance of cascade H-bridge SVG for reactive power compensation.

Keywords: Cascade H-Bridge Inverter, Static Var Generator, Carrier Phase-Shifted SPWM.

P1195

Modeling of Peripheral Circuit of Bus-integrated Computer Based on Saber

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Bus-integrated computers have a wide range of applications in the aerospace field. But few of them use Saber for simulation modeling of bus-integrated computers. Using Saber modeling, it is possible to target device level, subsystem level and supersystem simulation, which facilitates faster development iterations and shorter development time.

To address this issue, this paper first uses Saber to model its peripheral circuits for bus- integrated computers. The model mainly contains power supply module, filter module, I/O interface, and CAN bus interface. After that, the constant power load model is used to abstract the rest parts of the bus-integrated computer. By running the simulation, the effect of the model of the peripheral circuit on the constant power load is compared when it works and does not work, the parameters of the inductor in the system are corrected, and the voltage stability of the DC-DC converter is verified by feedback, which effectively improves the efficiency of the design iteration.

Keywords: Saber, Bus-integrated computer, Modeling and simulation, Negative feedback control.

P1196

Research on Modeling Method of Aeronautical Weapon Flight Control System Based on Harmony-SE

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This paper establishes the flight control system model using the Harmony-SE method, and realizes simulation of the aeronautical weapon trajectory from the launching point to the target point. The characteristic of flight control system of aeronautical weapon is that all functions revolved around the calculation and iteration of system state. Since the main idea of Harmony-SE is to design the system architecture and system function based on use cases, there are redundant steps such as analyzing the context of use cases in the process of modeling the system with this characteristic, which is inefficient. To solve this problem, this paper puts forward an optimization method. On the basis of Harmony-SE, this paper optimizes the architecture analysis and design method based on the function flow in the Harmony-SE method, simplifies the system model architecture, proposes the architecture design method based on the information flow, which simplifies Harmony-SE steps by using the information flow to suture function flow, thus improve the modeling efficiency of the flight control system.

Keywords: Harmony-SE, Flight Control System, Modeling aand Simulation, Information Flow.

P1200

Route Planning of Mixed Ant Colony Algorithm Based on Dubins Path

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Nowadays, with the rapid development of UAV and robot technology, the route planning of UAV and robot has become an inevitable problem. How to design a high precision and high reliability algorithm to guide the UAV or robot to the target point with the optimal path and avoid obstacles and threats in the path has become a hot research topic. In this paper, the grid system is used to divide the map into two values to determine the passable area and the threat area. In the route planning, the pheromone concentration and heuristic information are set based on the ant colony algorithm, and the heuristic factor is improved on the basis of the traditional ant colony algorithm. Thus, the improved algorithm can solve a feasible path and speed up the convergence speed. At the same time, Dubins curve is used to curve the solution path, so that the path can meet the requirements of flight curvature of UAV. In addition, this paper compares the difference between the improved ant colony algorithm and the traditional ant colony algorithm, and tests the influence of different parameters in the hybrid ant colony algorithm on the algorithm effect.

Keywords: Route Planning, Ant Colony Algorithm, Dubins Path.

P1211

Distributed Optimal Power Dispatch Based on Bisection Lambda Iteration Algorithm for Microgrids

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A microgrid central controller (MGCC) is a conventional approach to achieve power management for microgrids. It is inherited from the matured power system control structure where the generations are concentrated. However with the nature of distributed energy resources (DERs) in microgrids, a centralized controller may not be advantageous anymore. In addition to the computational burden and heavy communication traffic, any communication breakdown or malicious attack on MGCC could pose a high risk of breaking down the entire microgrid. A distributed optimal power allocation algorithm is proposed in this paper to decompose the MGCC functionality and distribute it among each of the DERs. Each DER controller is able to work cooperatively to achieve the optimal power allocation through only limited information exchange with its neighboring DER controllers. A new distributed bisection λ- iteration algorithm is proposed to achieve an optimal power sharing among all the dispatchable DERs. Simulation results with an MG test system consisting of several types of DERs also demonstrate and verify the effectiveness of the proposed distributed optimization strategy.

Keywords: Cyber–physical system; Distributed framework; Optimal power allocation; Lambda iteration; microgrid.

Session	SS25 Special Invited Session (4)
Date	1 – 14 August 2021

P1216

Adaptive Backstepping Control of Uncertain Electro-Hydrostatic Actuator with Unknown Dead-zone Nonlinearity

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This paper proposed an adaptive backstepping control scheme for the position tracking problem of Electro-Hydrostatic Actuator (EHA) with unknown dead-zone nonlinearity, parameter uncertainties and mismatched disturbances. Different from previous results,

the boundaries of uncertainties, nonlinearity and disturbances can be completely unknown. Moreover, some of the uncertain parameters are time-varying and non-differentiable. To eliminate the effect of nonlinearity, parameter uncertainties and disturbances caused by the change of load and environmental conditions, a series of quadratic compensated terms and adaptive update laws combined with modification factor are introduced. Through stability analysis, it is proved that the proposed method is globally stable and the position tracking error can converge to the arbitrarily small compact set. Simulation results demonstrate that the proposed control algorithm is effective.

Keywords: Electro-Hydrostatic Actuator, Nonlinear system, Dead-zone, Adaptive control, Backstepping.

P1229

Research on Rotor Position Estimation of PMSM Based on Hall Position Sensor

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The sine wave drive technology of permanent magnet synchronous motor based on Hall sensor is a rotor position detection technology that can ensure the running performance of the motor, and at the same time can effectively control the system cost and improve the reliability of the system. It has attracted wide attention from scholars at home and abroad. However, the actual three-phase Hall signal has a certain deviation from the ideal situation, which causes the accuracy of motor speed and rotor position estimation to decrease, thereby affecting the control performance of the motor. This article first introduces the working principle of the Hall position sensor, and then discusses two different rotor position estimation schemes based on the three-phase Hall position sensor. In view of the imperfect Hall signal, a frequency tracking filter is proposed to improve the observation performance of the position vector observer, and finally verify the performance of the scheme through simulation.

Keywords: Hall Sensor, Rotor Position Estimation, Position Vector Observer, Frequency Tracking Filter.

P1251

Human-machine Coupled Research of a Passive Lower Limb Exoskeleton for Walking Assistance

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Lower limb exoskeleton is a human-machine-electric system that is worn on the outside of the human body and incorporates advanced control, information and communication technologies. It can provide protection, support, and certain auxiliary power for the wearer. In this paper, the mechanical structure of a lower limb exoskeleton is designed and coupled with the human body model for simulation. it verifies the effect of the exoskeleton in reducing human metabolic consumption. First of all, this paper introduces the overall structural design of a lower limb exoskeleton. Secondly, the forward and inverse kinematics of the exoskeleton leg are analyzed, and the working space and Jacobian matrix of the exoskeleton are solved. Finally, the human-machine coupled simulation of the exoskeleton is carried out to analyze the metabolic consumption of the human body under different conditions and verify the power-assisting effect of the exoskeleton on human walking.

Keywords: Exoskeleton, Mechanical Design, Kinematics Analysis, Human-Machine Coupled Simulation

P1256

Design and Optimization of Human-Machine Interaction Wearable Device for Lower Limb Rehabilitation Exoskeleton

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In this article, we designed a wearable device for the lower limb rehabilitation exoskeleton robots. The device is mainly composed of three parts: a slide rail mechanism, a detecting human-machine interaction force structure and a binding part. By adding passive degree of freedom to automatically compensate for the joint axis deviation between the exoskeleton and the human body, thereby reducing the radial parasitic force on the human leg. In order to verify the effect of automatic compensation of passive degrees of freedom, we conduct statics modeling for human-robot interaction coupling. At the same time, we also designed a device for detecting interaction force, which can obtain human movement intentions in rehabilitation training, and provide a hardware foundation for the research of human-robot cooperative control of rehabilitation exoskeleton. The detection device has the advantages of low cost, compact structure, and good detection performance.

Keywords: Rehabilitation Exoskeleton, Interaction Force Detection, Human-Robot Coupling, Wearable Device.

P1269

Formation Control and Obstacle Avoidance of Mas With Constraints of Visibility and Motion Saturation

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This paper proposes a multi-agent formation and movement method based on the leader-follower architecture and visual sensor signals.

This method uses a depth camera as the source of information perception in the leader's local environment. After image acquisition and image processing, the external environment information and the obstacle position signal are input into the leader's control system. The controller drives the actuator to avoid obstacles and complete the consistency under weak or without communication conditions Firstly, in view of the hardware limitations of the vision sensor itself, this paper analyzes the saturation constraints of field of view, and couples it with the motion constraints of the actual subject. Secondly, for the coupled constraints, a correction system is used in the design of the negative gradient control law based on the stress matrix. Finally, for the designed closed-loop control system, the stability analysis is carried out using the Lyapunov function, and the error in the modified control protocol is converged. Static and dynamic obstacle avoidance processes are represented by simulation in Matlab.

Keywords: Visual Sensing, Visibility Constraint, Motion Saturation, Obstacle Avoidance.

P1285

Evaluation of Transformer Bushing Moisture Faults Based on Clustering Algorithms and TOPSIS

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With the continuous expansion of the scale of power grids, the amount of monitoring data of power equipment is growing and the reliability demand of power equipment is increasing. In order to cope with power transformer accidents caused by damp faults in oil-immersed bushings, this paper applies big data clustering technology to construct a bushing damp fault evaluation index system, and combines the posting progress obtained from TOPSIS method to achieve a quantitative assessment of the damp state of bushings. The effectiveness of this method is also verified with examples.

Keywords: Clustering Algorithm, TOPSIS, Bushing, Fault Assessment.

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P1286

Key Factors Affecting the Corona Onset Voltage of Electrostatic Precipitator Electrodes

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In this paper, based on COMSOL simulation,a simulation model of corona initiation for angular electrodes with different number of tips (quadrangular, hexagonal, octagonal), tip thickness (0.3 cm, 0.5 cm, 0.8 cm), and angle (10.72°, 16°, 20.72°) is established to investigate the effect of changes in the geometry of angular electrodes. The effect of the change of the angle electrode geometry on the corona onset voltage is investigated. By introducing the concept of equivalent radius, the effect of geometric variations in the number of tips, thickness and angle on the corona onset voltage was quantified. It was found that as the number of tips, tip thickness and angle of the angular electrode decreased, the equivalent radius of the angular electrode gradually decreased and the corona onset voltage gradually decreased; variations in the number, thickness, and angle of the unit tip had differences in the degree of influence on the corona voltage, with rates of 3.279%, 2.846%, and 0.678%, respectively.

Keywords: Electrostatic Precipitator, Angular Electrode, Geometry, Corona Onset Voltage.

P1288

Wear Modelling of Slipper/Swashplate Pair for High-Speed Piston Pump Under Transient Lubrication Conditions

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Wear phenomenon occurring in the slipper/swashplate pair of the high-speed piston pump is investigated in this paper. Analytical model along with the finite difference method is adopted to solve the transient thermo-elastohydrodynamic (TEHD) lubrication process. The proposed approach considers the slipper wear clearance and deformations caused by thermal deflection and hydrostatic pressure. The results show that the lubricating oil film is unevenly distributed. Consequently, discrete friction area wear model is proposed to account for the partial abrasion characteristics. In addition, the slipper wear profile is dynamically updated with the pump working time extended. The simulation results indicate that the wear of the slipper pair can be reduced by operating the pump within the high-speed/low pressure/small displacement zone.

Keywords: Axial Piston Pump, Slipper/Swashplate Pair, Lubrication, Wear.

P1415

Learning From Demonstration Using Improved Dynamic Movement Primitives

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It is important to endow the robot with the ability of learning the complex motion sequences and thus adopt such motions when facing to changeable environment. This paper proposes an improved Dynamic Movement Primitives (DMP) method. In order to solve the problem of invalidation of forcing term in conventional DMP, the improved DMP approach, i.e., the DMP together with Deep Neural Network (DNN), isproposed. Specially, DNN is introduced to fit the target non-linear function with the demonstrated trajectory information, instead of using a specific formula to describe the forcing term in DMP. Thus, improved DMP method can avoid the drawback of conventional DMP. Simulation work is conducted and the results show that the invalidation performance of forcing term is improved compared with conventional DMP. In addition, the generalization property of improved DMP is also beneficial to work environmental adaptability.

Keywords: Trajectory learning, DMP, DNN, Fitting of non-linear function.

P1419

Toward Obstacle Avoidance for Mobile Robots Using Deep Reinforcement Learning Algorithm

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The state-of-the-art deep reinforcement learning algorithm, i.e., the deep deterministic policy gradient (DDPG), has achieved good performance in continuous control problemsfor the robotics. However, the conventional experience replay mechanism of the DDPG algorithm stores the experience explored by the mobile robot in the bufer pool, and trains the neural net-work through random sampling, without considering whether the transition is valuable, which can probably influence the network performance. To overcome the limitation, the DDPG framework with separating experience is developed for mobile robot collision-free navigation in this study, to replay the transitions of valuable and the failed experience discretely. Additionally, environment state vector is designed including mobile robot and obstacles, the reward function and action space are also designed. The simulation results show that the proposed model can possess the collision-free navigation capacity to deal with multiple obstacles.

Keywords: Mobile Robot, Obstacle Avoidance, Deep Deter-Ministic Policy Gradient.

P1420

Torque Density Optimization of Six-phase Permanent Magnet Synchronous Machine

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Compared with the three-phase permanent magnet synchronous motor (PMSM), the six-phase PMSM has better winding fault-tolerance performance, which greatly improves the safety of the electromechanical actuation (EMA) of the aerospace crafts. The typical structure of the six-phase PMSM is 12 slots, 10 poles, concentrated winding, parallel magnetization, and has the ability to restrain short-circuit current. Although parallel magnetization is simple, the output torque is limited. In this paper, a magnet array design method based on parallel magnetization, oblique magnetization, and tangential magnetization is proposed, which improves the torque density of the six-phase PMSM and reduces the torque ripple at the same time. According to the specific requirements of the EMA, four six-phase permanent magnet synchronous motors with different magnet arrays including parallel magnetization are designed. Through finite element analysis (FEA), the air gap radial magnetic density of different magnet arrays is obtained. The influence of the air gap radial magnetic density on the output torque and torque ripple is analyzed. The simulation result shows that the proposed magnet array design method can improve the torque density of the six-phase PMSM and reduce the torque ripple compared with parallel magnetization.

Keywords: Permanent Magnet Synchronous Motor, Magnet Arrays, Torque Density, Gap Radial Magnetic Density.

P1421

Design and Optimization of BLDC Machine for Bidirectional Impeller Pump

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The bidirectional impeller pump is a kind of double impeller pump driven by single motor, which can pump and drain water with a single pump. This design effectively overcomes the disadvantages of complicated pipeline arrangement and poor reliability caused by multi-pump operation. In this paper, a bidirectional impeller pump is designed, which can realize the two-way flow of fluid through a special flow channel topology, and the structure and electromagnetic design of the core drive component of the permanent magnet brushless DC motor are carried out. The magnetic field numerical model of the motor is established by Maxwell, and the distribution characteristics of the air gap magnetic field and electromagnetic output characteristics are simulated and analyzed. Taking the output power and efficiency as the optimization objectives, the motor parameters such as the number of turns and wire diameter are optimized. The prototype and the experimental platform for the output characteristics of the bidirectional pump are designed and processed. The simulation results and the rationality of the structure are verified through experiments.

Keywords: Bidirectional Impeller Pump, BLDC Motor, Structural Design, Electromagnetic Simulation.

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