2017 8th IEEE Conference on Cybernetics and Intelligent Systems (CIS) & Robotics, Automation and Mechatronics (RAM)

19-21 Nov 2017
Ningbo, China

PROGRAM & ABSTRACTS

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Welcome Message

A warm welcome to the IEEE CIS-RAM 2017 in Ningbo, China!

It is our pleasure to welcome you all to the 2017 IEEE CIS-RAM taking place in Pan Pacific Ningbo Hotel.

The conference aims to bring together an international community of professionals to discuss the novel, state-of-the-art results, perspectives of future developments and innovative applications on cybernetics and intelligent systems (CIS), as well as mechatronics, robotics, automation (RAM) and related areas.

This year we have received more than 200 initial submissions, where eventually about 150 papers are accepted for oral presentation after thorough peer review. These will be presented during 3 days in 3 tracks, 24 sessions. In addition, it is our honor to have three excellent experts to deliver us the wonderful keynote speeches: Professor Frank PARK from Seoul National University, Professor Philip CHEN from University of Macau, and Professor Feng GAO from Shanghai Jiao Tong University.

The organization committee have worked very hard to prepare the wonderful program of extra-high quality. We highly appreciate the professional contribution from advisory committee members, authors, reviewers, associate editors, regular and invited session chairs resulting in the fantastic quality of technical program and the proceedings.

Moreover, we hope that you will enjoy your time in Ningbo. Located in the south wing of Yangtze river delta economic zone, 2 hour by car or train from Shanghai, Ningbo and surrounding offers a number of places of interests, such as Confucian Wang Yang Ming (王阳明)'s former home, Tianyi Pavilion (天一阁), Dongqian Lake (东钱湖), Chiang Kai Shek's ancestral residence (蒋氏故居). Our Banquet, organized in Pan Pacific Hotel, will give you a taste of the Zhejiang, and we hope that you will also enjoy the technical tour to Ningbo Institute of Industrial Technology, the first National Research Institute set up by Chinese Academy of Sciences in Zhejiang Province.

The great efforts of the local organization committee and student helps are highly appreciated. We would like to thank everybody who contributed to make IEEE CIS-RAM 2017 a success and wonderful one!

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Conference & Event Venue

The conference will be held in **Pan Pacific Ningbo Hotel**, a 5 star luxury hotel.

Located at the gateway of Eastern China's fastest-growing economic zone, Pan Pacific Ningbo is a 5 star luxury hotel in China ideally situated in the emerging Yinzhou district of Ningbo. Enjoy easy access to business services and facilities in the vicinity such as the Ningbo International Conference Exhibition Centre, Ningbo Culture Plaza, Century Oriental Shopping Centre and other charming local attractions.

Their 415 spacious rooms offer unique sanctuary exuding a sense of modern vibrancy and warmth, with a variety of thoughtful facilities allowing you to recharge and rejuvenate during your stay.

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Direction and Transportation

Location Map

Coming to Pan Pacific Ningbo Hotel

✧ **To arrive at Ningbo Lishe Airport.**

- Taxi from Ningbo Lishe Airport: Fare about CNY 70
- Public Transport from Ningbo Lishe Airport
  1. By the single trip ticket to (**Shiji Avenue**, *Shi Ji Da Dao*, “世纪大道” in Chinese)
  2. From Ningbo Lishe Airport, **take Metro Line 2** (Red Line) toward Qingshuipu “清水浦” Direction, alight at Gulou “鼓楼”, **exchange to Metro Line** 1 (Blue Line) toward Xiapu “霞浦” direction.
  3. **Take Metro Line 1** (Blue Line) for 6 stops, alight at **Shiji Avenue**, (*Shi Ji Da*

Dao, “世纪大道” in Chinese).

4. **Take Bus 521** (CNY 2) from *Zhongshan Huating* “中山华庭” toward Gongjiao Huizhang Lu “公交会展路” direction for **2 stops,** alight at *Min An Dong Lu Kou* “民安东路口”。
5. Pan Pacific Hotel is along the main road Min An Dong Lu “民安东路”, on the next traffic junction.

✧ **To arrive at Shanghai or Hangzhou, and take CRH Train to Ningbo Railway Station.**

- Taxi from Ningbo Railway Station: Fare about CNY 40
- Public Transport from Ningbo Railway Station.
  1. By the single trip ticket to (**Shiji Avenue**, *Shi Ji Da Dao*, “世纪大道” in Chinese)
  2. **Take Metro Line 2** (Red Line) toward Qingshuipu “清水浦” Direction, the remaining steps are the same as from the airport to Pan Pacific Hotel.

Floor Plan of Conference Center

Ocean Tower
3F Layout

PAN PACIFIC
NINGBO
宁波泛太平洋大酒店

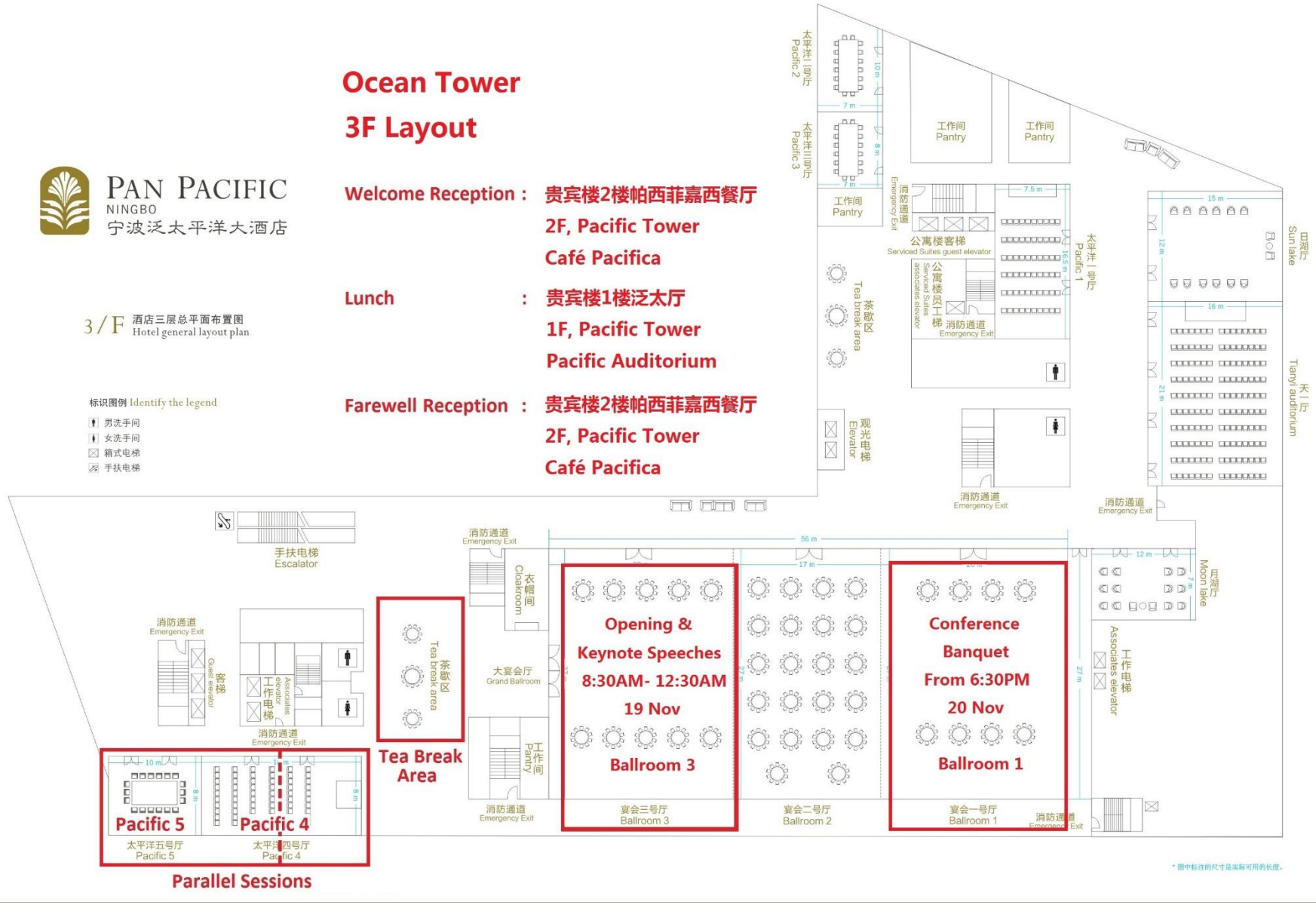
3 / F 酒店三层总平面布置图
Hotel general layout plan

标识图例 Identify the legend
- 男洗手间
- 女洗手间
- 箱式电梯
- 手扶电梯

Welcome Reception : 贵宾楼2楼帕西菲嘉西餐厅
2F, Pacific Tower
Café Pacifica

Lunch : 贵宾楼1楼泛太厅
1F, Pacific Tower
Pacific Auditorium

Farewell Reception : 贵宾楼2楼帕西菲嘉西餐厅
2F, Pacific Tower
Café Pacifica



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Pan Pacific Ningbo Hotel 泛太平洋酒店

Hotel Address	99 Min An Dong Lu, Yinzhou District, 315042 鄞州区民安东路 99 号
Reservation Email Address	reserve.ppngb@panpacific.com
Contact Person	Donna Dong 董朱红: (+86) 15858405002
Price	CNY450/Night (Net Price)
Room Type	superior king room/superior twin room (高级大床房/高级双床房)

Howard Johnson IFC Plaza Ningbo Hotel 宁波逸东豪生大酒店

Hotel Address	No.288 Dingtai Road, Yinzhou District, Ningbo, 315040 鄞州区·鼎泰路 288 号
Reservation via official page	www.whghotels.cn
Reservation via hotel front-desk hotline	86-574-81878888
Price	CNY450/Night (Net Price)
Room Type	superior king room/superior twin room (高级大床房/高级双床房)

Nanyuan Conventional Business Hotel 南苑会展商务酒店

Hotel Address	NO.181,Huizhan Road, Yinzhou District, 315042 (1.77km from Metro Station: Haiyan North Road) 鄞州区会展路 181 号宁波国际会展中心东门
Reservation via hotel front-desk hotline	86-574-55665678
Price	CNY240/Night (Net Price)
Room Type	superior king room/superior twin room (高级大床房/高级双床房)
To enjoy the special price, please kindly inform them that you are the delegate of IEEE CIS-RAM conference.	

Program Overview

Time	Conference Program (18/Nov/2017)					
17:30	Welcome Reception					
Time	**Conference Program Day 1 (19/Nov/2017)**					
08:30	**Opening Ceremony** **by Prof. Guilin YANG**					
09:00	**Keynote 1: Recent Advances and Open Challenges** **in Robot Assembly and Inspection** **by Prof. Frank Chongwoo PARK**					
10:00	Tea Break					
10:20	**Keynote 2: Generative and Discriminative Learnings:** **A Fuzzy Restricted Boltzmann Machine and a Novel Broad Learning System** **by Prof. C. L. Philip CHEN**					
11:20	**Keynote 3: Design and Control of 6-Legged Parallel-Parallel Robots** **for Moving and Manufacturing Integration,** **by Prof. Feng GAO**					
12:20	Lunch					
13:40	**Pacific hall 4A**	**SuAT1: Kinematics & Dynamics of Manipulators**	**Pacific hall 4B**	**SuAT2: Vehicles and Navigation I**	**Pacific hall 5**	**SuAT3: Industrial Robotics I**

15:25	Tea Break					
15:45	**Pacific hall 4A**	**SuBT1: Aerospace Control Systems and Applications I**	**Pacific hall 4B**	**SuBT2: Vehicles and navigation II**	**Pacific hall 5**	**SuBT3: Power, Communications and Networks**
17:15						
Time	**Conference Program Day 2 (20/Nov/2017)**					
08:30	**Pacific hall 4A**	**MoAT1: Biomechanics I**	**Pacific hall 4B**	**MoAT2: Devices - Electromagnetic I**	**Pacific hall 5**	**MoAT3: Identification and Control I**
10:00	Tea Break					
10:20	**Pacific hall 4A**	**MoBT1: Medical Robotics**	**Pacific hall 4B**	**MoBT2: Devices - Thermo and Hydraulic**	**Pacific hall 5**	**MoBT3: Identification and Control II**
11:50	Lunch					
13:40	**Pacific hall 4A**	**MoCT1: Measurements and Estimation**	**Pacific hall 4B**	**MoCT2: Mechanics & Mechanisms**	**Pacific hall 5**	**MoCT3: Soft Robotics and Industrial Robotics II**
15:25	Tea Break					
16:00	**Pacific hall 4A**	**MoDT1: Aerospace Control Systems and Applications II**	**Pacific hall 4B**	**MoDT2: Devices - Electromagnetic II**	**Pacific hall 5**	**MoDT3: Identification and Control III**
18:00	**Conference Banquet**					
	Conference Program Day 3 (21/Nov/2017)					

08:30	**Pacific hall 4A**	**TuAT1: Devices - Vibrations**	**Pacific hall 4B**	**TuAT2: Machine Learning**	**Pacific hall 5**	**TuAT3: Vision and Inertial Sensing**
10:00	Tea Break					
10:35	**Pacific hall 4A**	**TuBT1: Parallel Mechanisms & Actuation/Environment**	**Pacific hall 4B**	**TuBT2: Biomechanics II**	**Pacific hall 5**	**TuBT3: Aerospace Control Systems and Applications III**
12:20	Lunch					
13:30	**Technical and Culture Tour**					
17:30	Farewell Reception					

Keynote Speech 1

Recent Advances and Open Challenges in Robot Assembly and Inspection

Frank Chongwoo PARK, Ph.D., FIEEE

Professor, School of Mechanical & Aerospace Engineering
Seoul National University
Editor-in-Chief, IEEE Transactions on Robotics

Abstract

Despite the visions of a smart, connected, unmanned and continuously operating factory in every neighborhood, enabled by recent advances in robotics, IoT, machine learning, and cloud automation and manufacturing, most of today's smaller factories are far removed from this vision. Humans still do most of the parts fitting, assembly, inspection, and testing. In this talk I will examine some of the technological and economic factors behind this reality. I will also argue that a paradigm shift toward minimalism is what is needed: Simpler, lower-cost automation devices that are flexible and easily reconfigurable, driven by advanced algorithms and software, offer the greatest promise of bringing practical automation to today's manufacturing and assembly factories. I will outline what existing technologies and methods can be leveraged for immediate impact, and what some of the near- and longer-term technical challenges are that must be overcome. In particular, open problems in robot motion control, and also automated inspection and testing methods that leverage recent advances in machine learning, will be discussed.

Short Biography

Frank Park received his B.S. in EECS from MIT in 1985, and Ph.D. in applied mathematics from Harvard University in 1991. He joined the mechanical and aerospace engineering faculty at the University of California, Irvine in 1991, and since 1995 he has been professor of mechanical and aerospace engineering at Seoul National University, where he is currently serving as department chair since June 2017.

His research interests are in robot mechanics, planning and control, vision and image processing, machine learning, and related areas of applied mathematics. He has been an IEEE Robotics and Automation Society Distinguished Lecturer, and received best paper awards for his work on visual tracking and parallel robot design. He has served on the editorial boards of the Springer Handbook of Robotics, Springer Advanced Tracts in Robotics (STAR), Robotica, and the ASME Journal of Mechanisms and Robotics. He has held adjunct faculty positions at the NYU Courant Institute and the Interactive Computing Department at Georgia Tech, and is currently adjunct professor at the Robotics Institute at HKUST. He is a fellow of the IEEE, current editor-in-chief of the IEEE Transactions on Robotics, developer of the EDX course Robot Mechanics and Control I, II, and co-author (with Kevin Lynch) of Modern Robotics: Mechanics, Planning and Control (2017 Cambridge University Press).

Keynote Speech 2

Generative and Discriminative Learnings: A Fuzzy Restricted Boltzmann Machine and a Novel Broad Learning System

C. L. Philip CHEN, Ph.D., FIEEE, FAAAS

Dean and Chair Professor
Faculty of Science and Technology, The University of Macau, Macau, China
Editor-in-Chief, IEEE Transactions on Systems, Man, and Cybernetics: Systems
Philip.Chen@ieee.org

Abstract

In recent years, deep learning caves out a research wave in machine learning. With its outstanding performance, more and more applications of deep learning in pattern recognition, image recognition, speech recognition, and video processing have been developed. This talk will introduce a fuzzy generative deep learning algorithm and a novel broad learning systems. A fuzzy generative learning -- Fuzzy Restricted Boltzmann Machine (FRBM) -- is developed by replacing real-valued weights and bias terms with symmetric triangular fuzzy numbers (STFNs) or Gaussian fuzzy numbers and corresponding learning algorithms. A theorem is concluded that all FRBMs with symmetric fuzzy numbers will have identical learning algorithm to that of FRBMs with STFNs. The second part of the talk is to discuss a very fast and efficient discriminative learning. Without stacking the layer-structure, the designed neural networks expand the neural nodes broadly and update the weights of the neural networks incrementally when additional nodes are needed and when the input data entering to the neural networks continuously. The designed network structure and learning algorithm are perfectly suitable for modeling and learning big data environment. Experiments results in MNIST and handwriting recognition and NORB database indicate that the proposed BLS significantly outperforms existing deep structures in learning accuracy and generalization ability.

Short Biography

C. L. Philip Chen is currently the Dean of the Faculty of Science and Technology, University of Macau, Macau, China and a Chair Professor of the Department of Computer and Information Science since 2010. He worked at U.S. for 23 years as a tenured professor, a department head and associate dean in two different universities. Dr. Chen's research areas are in systems, cybernetics and computational intelligence. He is a Fellow of the IEEE and AAAS. He was the President of IEEE Systems, Man, and Cybernetics Society (SMCS) (2012-2013). Currently, he is the Editor-in-Chief of IEEE Transactions on Systems, Man, and Cybernetics: Systems (2014-).

Dr. Chen has been an Associate Editor of many IEEE Transactions, and currently he is an Associate Editor of IEEE Trans on Fuzzy Systems, IEEE Trans on Cybernetics, and IEEE/CAA Automatica Sinica. He is the Chair of TC 9.1 Economic and Business Systems of IFAC. He is also a Fellow of CAA and Fellow of HKIE and an Academician of International Academy of Systems and Cybernetics Science (IASCYS). In addition, he is an ABET (Accreditation Board of Engineering and Technology Education, USA)

Program Evaluator for Computer Engineering, Electrical Engineering, and Software Engineering programs.

Dr. Chen has received Outstanding Electrical and Computer Engineering Award in 2016 from his alma mater, Purdue University, West Lafayette, where he received his Ph.D. degree in 1988, after he received his M.S. degree in electrical engineering from the University of Michigan, Ann Arbor, in 1985.

Keynote Speech 3

Design and Control of 6-Legged Parallel-Parallel Robots for Moving and Manufacturing Integration

Feng GAO, Ph.D. , winner of 2013 China National Natural Science Award

State key laboratory of mechanical system and vibration, School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai, 200240, China

Abstract

Research on the walking robots has been one of key topics in robotics for a long time. In recent years, many legged robots were developed in the world, which of them achieved great progress and received much attention from the robotic field. The most important challenging issues are the design and human robot Interaction control of the legged robots. This speech will introduce our research on both mechanism design and real time control of the 6-legged parallel-parallel robots for the moving and manufacturing integration, which include the following issues: design process of type synthesis for legged robots by GF set theory, real-time operating system for legged robots, hexapod robot with safe riding capability, walking based on force sensing., obstacle avoidance with both vision and F/T sensor, walking upstairs by vision, human-robot interactive assembly based on F/T sensor, manufacturing based on F/T sensor, locked door opening based on F/T sensor for legged robots, and so on.

Short Biography

Feng Gao was born on Dec. 21, 1956 in Jiujiang City of Jiangxi Provence, P. R. of China. He got his Ph.D. in mechanical engineering from the Beijing University of Aeronautics and Astronautics in 1991 and his Master in mechanical engineering from the Northeast Heavy Machinery Institute, China in 1982. From 1995 to 1997, he was a postdoctoral research associate in the School of Engineering Science at Simon Fraser University, Canada.

He has been serving as an Associate Editor of Mechanism and Machine Theory and the ASME Journal of Mechanisms and Robotics since 2008 and the ASME Journal of Mechanical Design since 2012, and the General Member of the ASME Mechanisms and Robotics Committee since 2012. He gave the Keynote Speeches on the conferences of the ASME 2012 and IFToMM 2015, respectively. He won the 2013 China National Natural Science Award because of his contributions in parallel mechanism design and the 8 items of awards from the provincial science and technology invention prizes in China. 2014. Dr. Gao won 2014 ASME Leonardo Da Vinci Award for his invention of parallel manipulators.

His chief research domain is the parallel robots. The major achievements obtained include the design theory, invention and application of the parallel robots. In the theory aspect, he proposed the GF Set Theory for the type synthesis of parallel robotic mechanisms, the evaluating performance criteria and the physical model of the solution space for dimensional designing of parallel robotic

mechanisms. In the application aspect, he Invented and Designed many kinds of the robots and machines with parallel mechanisms for heavy load applications He published 3 books and 288 papers. The 120 invention patents were authorized in China.

Social Program & Technical and Culture Tour

Welcome Reception

Saturday, 18 Nov 2017, from **17:30hr** at 2F, Pacific Tower Café Pacifica (贵宾楼 2 楼帕西菲嘉西餐厅).

Conference Banquet

Monday, 20 Nov 2017, from 18:00hr at 3F, **Ocean Tower** Ballroom1 (迎宾楼 3 楼大宴会 1 号厅).

Technical and Culture Tour

Tuesday, 21 Nov 2017, 13:30–17:30hr.

To visit Tianyi Pavilion (天一阁) and Ningbo Institute of Industrial Technology, CAS (CNITECH). Transportation will be arranged from Pan Pacific Ningbo Hotel at **13:30hr**. Please kindly indicate your attendance latest by **15 Nov 2017**.

Farewell Reception

Tuesday, 21 Nov 2017, from 17:30hr at 2F, **Pacific Tower** Café Pacifica (贵宾楼 2 楼帕西菲嘉西餐厅).

Tea Break/Lunch

19-21 Nov 2017

- **19 Nov Morning Tea Break**: 10:00-10:20hr at 3F, **Ocean Tower** Ballroom 3 Foyer (迎宾楼 2 楼大宴会 3 号厅序厅).
- **Other Tea Breaks**: 10:00-10:20hr and 15:45-16:15hr at 3F, **Ocean Tower** Pacific 4-5 Foyer (迎宾楼 3 楼太平洋 4-5 号厅序厅).
- **Lunch**: 12:00-12:30hr at 1F, **Pacific Tower** Pacific Auditorium (贵宾楼 1 楼泛太厅).

Abstracts of Technical Sessions

Day 1: 19 November 2017

PM Sessions

Venue:	Pacific Hall 4A
Session:	**SuAT1:** Kinematics & Dynamics of Manipulators
Date/Time:	Sunday, 19 November 2017, 13:40 – 15:25
Chair:	Guilin Yang / Zhen Zhong
13:40 – 13:55 **PDF** [259]	**SuAT1.1:** The Kinematic Analysis and Stiffness Optimization for an 8-DOF Cable-driven Manipulator *Yi Wang, Guilin Yang, Kaisheng Yang and Tianjiang Zheng* This paper proposed an 8-DOF cable-driven robotic arm (CDRA) composed of four identical 2-DOF cable-driven joints with variable stiffness. The proposed cable-driven joints are equipped with variable stiffness devices to increase the stiffness adjustable range. Therefore, an inverse displacement algorithm is proposed for this redundant robotic arm using the conjugate gradient method. The quadratic sum of the joint angles is selected as an objective to minimize due to the character that the cable-driven joints has a larger stiffness range when the joint angle is small. With such algorithm, the joint angles will have a larger stiffness range. Then, the stiffness of the CDRA is analyzed with the body manipulator Jacobian employed. An optimization algorithm using similar conjugate gradient method is proposed to obtain the desired stiffness. Low cable tension level could be obtained with a "tension level index" employed in the optimization. A simulation of the algorithm is conducted and the result shows that such method is effective and computational efficient.
13:55 – 14:10 **PDF**[179]	**SuAT1.2:** Rotational axes and inverse kinematics analysis of a novel 5-DOF hybrid manipulator *Dongsheng Zhang, Yundou Xu, Jiantao Yao, Yongsheng Zhao and I-Ming Chen* This paper presents a novel five-degree-of-freedom (DOF) hybrid serial-parallel manipulator (HSPM). The parallel part of this HSPM is 2UPU/SP parallel mechanism (PM), and this PM has two rotational DOF and one translational DOF (2R1T). To better understand the structure, the principle of constructing the HSPM is introduced. As this parallel part belongs to an overconstrainted 2R1T PM, the constraint force/torque generated to the moving platform are analyzed. Incidentally, the rotational axes of the PM is obtained, which is helpful to well know its motion properties. Then inverse position of the HSPM is deduced. And to make it more geometric visualization, the reachable workspace of the PM is given. At last, numerical simulation involving five axis linkage processing is done, and the results show the correct of theoretical model. This research will lay good theoretical foundations for application of this novel manipulator.
14:10 – 14:25 **PDF** [185]	**SuAT1.3:** A research on inverse kinematics solution of 6-DOF robot with offset-wrist based on Adaboost Neural Network *Qun Shi and Jiajun Xie* Adaboost has been verified as an effective algorithm that improves the performance of

weak learning algorithms which are slightly better than random guessing. In this paper, we use Adaboost based feed forward neural network to solve the inverse kinematics of 6 Degrees-of-Freedom (DOF) robot with offset-wrist. The algorithm aims to overcome the dilemma that most robots with offset wrists can only be solved by numerical methods in low efficiency. Experiments indicate the algorithm has a good performance in both accuracy and stability by reducing more than 70\% of the average error and over 80\% of the variance, and the generalization ability of the strategy is quite effective by testing through severe cases.

14:25 – 14:40 **SuAT1.4:** Dynamics Modelling of a Mobile Manipulator with Powered Castor Wheels
PDF [271] *Wenji Jia, Guilin Yang, Lefeng Gu and Tianjiang Zheng*

This paper is devoted to the dynamic modelling of an omnidirectional mobile manipulator. The driving wheels of the mobile platform is powered castor wheels, and the dynamics of the platform is derived by Lagrangian method and the augmented object model. The dynamics of the manipulator atop the platform is obtained by Newton-Euler recursive method. The interaction force between the arm and the platform is also derived to complete the unified model. Final a simulation is used to verify the proposed dynamic model.

14:40 – 14:55 **SuAT1.5:** Dynamic Control with Tension Compensation of a 3-DOF Cable-driven Parallel Manipulator
PDF [217] *Bingyuan Zhang, Weiwei Shang and Shuang Cong*

Considering the unidirectional force characteristic of the cable, the dynamic model of winch unit is established under different conditions for a 3-DOF cable-driven parallel manipulator. Two controllers with tension compensation are proposed on the basis of the dynamic model: the dynamic control with tension feedforward compensation and the dynamic control with tension feedback compensation. The asymptotic stability of the closed-loop system under the two control laws is proved by the mean-value theorem for vectorial functions and the Lyapunov method. The trajectory tracking control experiments are implemented on an actual 3-DOF cable-driven parallel manipulator platform, and the experimental results indicate that the proposed two control methods can achieve high control accuracy.

14:55 – 15:10 **SuAT1.6:** Fuzzy-Neural-Network Based Position/Force Hybrid Control for Multiple Robot Manipulators
PDF [118] *Zhihao Xu, Xuefeng Zhou, Taobo Cheng, Kezheng Sun and Dan Huang*

This paper studies the position/force hybrid control problem for multiple robot manipulators (MRMS), where robots handle a common tool cooperatively. Since there exists closed chains in the physical structure, the position and velocity of each manipulator are strictly constrained by the common tool. Furthermore, dynamic uncertainties make the entire system more complicated and coupled. The kinematic and dynamic models are first built, and the control strategy is designed using the idea of position/force hybrid control. The position controller is mainly composed of a fuzzy-neural-network, which is used to compensate the nonlinear part including unknown dynamics, a coordinative control item is also introduced to reduce the mutual influence among the robots. The force controller consists of a feedforward term and a proportional control term. The stability of the closed-loop system is analyzed by Lyapunov theory. Simulations using the ADAMS and MATLAB software are carried out to verify the proposed control strategy.

15:10 – 15:25 **SuAT1.7:** Tracking and Vibration Control for a Space Robotic System with Rigid and Flexible

PDF [219]	Manipulators *Zhen Zhong and Xinxin Yang* In this paper, the dynamics and control for a space robotic system with rigid and flexible manipulators under bounded disturbances are presented. Based on assumed modes approach and Lagrangian method, the closed-form dynamic model of the space robotic system is developed. By using the singular perturbation technique, the displacements/joint angles and flexible modes are modeled as slow and fast variables, respectively. A composite control scheme of sliding mode control and active vibration control is derived to track the desired trajectory under bounded disturbances and suppress the vibration of flexible manipulator. With the proposed control scheme, the closed-loop stability of the space robotic system can be achieved. Numerical simulations are presented to demonstrate the effectiveness of the proposed control.

Venue:	Pacific Hall 4B
Session:	**SuAT2:** Vehicles and Navigation I
Date/Time:	Sunday, 19 November 2017, 13:40 – 15:25
Chair:	Dan Wei Wang / Hao Sun

13:40 – 13:55
PDF [143]

SuAT2.1: Semantic Mapping and Semantics-boosted Navigation with Path Creation on a Mobile Robot
Hao Sun, Zehui Meng and Marcelo H. Ang Jr

"Movable obstacles are challenges for robotic navigation in human living environments because they lead to frequent changes in pre-built maps. Such changes cause navigation failures and high costs in path replanning. In this paper, we focus on the problem of semantic mapping and semantics-boosted
navigation, introducing our intelligent robotic system that is capable of real-time belief-based scene understanding, object detection and recognition, as well as path creation strategy based on the semantic information. With deeper understanding of the environments, robotic navigation in cluttered environments filled with movable obstacles is improved. Scene understanding and object detection are achieved by our state-of-the-art Convolutional Neural Network (CNN) with multi-functions and then transformed into robotic beliefs using Bayes filtering to ensure temporal coherence. Object beliefs are further extended from 2D to 3D space with geometric feature detection and used for semantic mapping together with scene beliefs. Planning algorithm is designed to utilize semantic beliefs to create path through cluttered environments by manipulating movable obstacles at minimal costs. We evaluate the system on our robots with real human-living office scenarios."

13:55 – 14:10
PDF [153]

SuAT2.2: Range-Only Navigation Algorithm for Positioning of Deep-Diving AUV
Qiang Zhang and Wen Zhang

This paper describes a strong tracking UKF (STUKF) based method for the online estimation of positioning error of the deep-diving autonomous underwater vehicle (AUV) using only a set of acoustic ranges from a surface ship, while the AUV equipped with strap-down inertial navigation system (SINS) executes a spiraled path under the ship. This approach also can avoid the use of either a precisely calibrated (and consequently expensive) ultra short baseline (USBL), or a long baseline (LBL) system (which is expensive in ship time to deploy). Results of simulation finally are presented to support the hypothesis that an AUV when diving to 6000-m depth can be positioned to the accuracy commensurate with global positioning system (GPS) quality or better.

14:10 – 14:25
PDF [188]

SuAT2.3: Trajectory tracking control of a Miniature Autonomous Helicopter with Input and Output Constraints
Zhen Zhong and Shuzhi Ge

We propose an active control strategy for a miniature autonomous helicopter (MAH) with nonlinear input saturation in this paper. In order to deal with the effect of the input saturation, we design an auxiliary system and bring it into the active control design for the desired trajectory tracking based on a simplified MAH model. With the designed control, the stability of the closed-loop system is proven and obtained via Lyapunov's direct method and the effectiveness of the proposed control method is illustrated by the control performances in the numerical simulation."

14:25 – 14:40
PDF [244]

SuAT2.4: Simulation Research of Heave Compensation Winch Based on Virtual Prototype
Yunfei Chen and Tibing Xiao

Heave compensation system is one of the necessary equipment to ensure the normal operation of ultra-depth floating drilling. Based on direct drive volume control and hydraulic transformer energy-recycle technology, a new type of multifunctional energy-saving heave compensation winch (HCW), which has the functions of drilling winch, heave compensation and energy-recycle, is introduced. The mechanical structure design of HCW's actuator is finished with Solidworks software. The hydraulic simulation model of HCW's direct drive volume control power mechanism is established by using AMESim software. The HCW's virtual prototype is established by using the co-simulation method of AMESim and ADMAS software. The problem of contact collision modeling for meshing gear is solved. The simulation is carried out based on established virtual prototype. The simulation results show that the virtual prototype established is correct. The comparison of simulation result and theoretical calculation value of gear meshing force shows that the method of contact collision modeling for meshing gear is feasible. The results are helpful to study HCW's performance in all its aspects.

14:40 – 14:55
PDF [272]

SuAT2.5: Feature Extraction Method Based on 2.5-Dimensions Lidar Platform for Indoor Mobile Robots
Yu Yang, Guilin Yang, Tianjiang Zheng, Yingzhong Tian and Long Li

In this paper we proposed a lidar feature extraction method based on range measurement points from a novel designed 2.5-Dimensions lidar platform. For a conventional 2D laser scanner, only the planar information can be detected in once scan. In order to get more spatial information about the indoor (rectilinear) environment, a novel 2.5D lidar platform is designed by driving a 2D laser scanner up-and-down vibrating in a short distance using a voice coil motor. Then an effective feature extraction method is formulated based on the 2.5D laser point data. Compared with traditional method, these laser points are actually located in 3D environment that resulting the extracted data actually are strip-shaped which include more information than 2D data. In our experiment, the geometrical features of space edges and surfaces can be extracted accurately, these are useful for the indoor mobile robot localization at the indoor environment. The effectiveness of this approach is validated through experiments on ROS (Robot Operating System).

14:55 – 15:10
PDF [254]

SuAT2.6: Vision-based Lane Detection and Tracking for Driver Assistance Systems: a Survey
Hui Zhou and Han Wang

Lane detection and tracking has been an active research area in the past twenty years mainly for the driver assistance application. Due to the large variations of traffic scenes and illumination conditions, this problem causes the usage of diverse approaches and sensing modalities. In this paper, we review the vision-based lane detection and tracking methods complemented with other sensor information when necessary. Approaches that adopt conventional computer vision techniques are reviewed and compared according to the separate functional modules in a generic framework. The recently developed machine learning especially deep learning based methods in the limited literature are analysed and also discussed, demonstrating high potential in the current and future challenging lane perception scenarios. While impressive achievements have been demonstrated under limited scenarios, new ideas and approaches are still desired such that the next generation robust and efficient system can be built in the service of autonomous vehicles.

15:10 – 15:25
PDF [003]

SuAT2.7: QUADO: an Autonomous Recharge System for Quadcopter
Zhi-Ning Liu, Zhi-Hao Wang, David Leo, Hong-Wei Zhao and Xia-Qing Liu

In this paper we present a new design of an auto-recharge drone system consist of drones auto-landing program and recharging ground stations, working with battery swapping and charging structure. Recently the application of drones expanded fast, drones for aerial photography or other entertainment use are no longer the only thing micro drones can do. Companies like Amazon are starting to consider the use of drones in their day-to-day business, also the Chinese ministry of electric power already have some special built quadcopter-drone to do wire inspection work. As micro drones will have more and more use-cases, the limited battery life becomes the main restriction on their using in long-time-flying missions. We argue that this problem can be solved in other ways than mere brute force. With camera and infrared (IR) sensor, drones in this system can landing accurately on the station to replace the battery. This system is a prototype system, includes the design of the battery swapping mechanisms and the landing control system with test results.

Venue:	Pacific Hall 5
Session:	**SuAT3:** Industrial Robotics I
Date/Time:	Sunday, 19 November 2017, 13:40 – 15:25
Chair:	Fei Zhao / Domenico Campolo

13:40 – 13:55
PDF [225]

SuAT3.1: Instrumentation of a grinding tool for capturing dynamic interactions with the workpiece
Gia-Hoang Phan, Sreekanth Kana and Domenico Campolo

Challenging continuous contact type tasks which require position, as well as force control, are still carried out manually by skilled labor (such as finishing, deburring and grinding). As it's difficult to program experienced users skill for a robotic setup without having a clear knowledge of underlying model used by the workers. We propose a novel method for instrumenting hand-held tools for capturing skilled operators function during tooling tasks. The information can be used in modeling a control algorithm for automating skilled tasks. The paper presents the hardware design of the instrumented tool including its calibration, followed by an experiment to validate tools ability to measure point of contact and applied forces accurately when the tool is fixed.

13:55 – 14:10
PDF [158]

SuAT3.2: Automatic Finishing System Research for Industrial Robot
Chin-Yin Chen, Junjie Li, Yindan Zhu, Liyan Tu and Wenwu Weng

This paper aims to develop an automatic finishing system on basis of industrial robot, which consists of compliant device, finishing process study and automatic trajectory planning, applied to the carbon fiber composite material. This compliant device applies combination of a pneumatic passive and spindle to a pressure control. It takes the advantage of constant force output, simple, stability force controlling, and fast response compare with conventional finishing device. Besides, for the sake of getting better quality of surface, the process parameters are studied by this system. On account of conventional robot programming of finishing is time consuming and not cost-effective. It is generally believed that a quick automatic trajectory planning is based on the data of cutter location (CL) and generated in CAD/CAM system be considered. It is not only explores a proper way to convert the G codes but also obtain data from CL to robot program directly through Visual Studio. Therefore, on basis of these studies, the “roof beam” was finally grinded automatically to verify the feasibility and practicability of this system.

14:10 – 14:25
PDF [275]

SuAT3.3: Development of an Industrial Robot Controller with Open Architecture
Luping Chen, Yuqiang Wu, Zhiguo Du, Tao Tao and Fei Zhao

This paper proposed a design and implementation method for industrial robot controller with open architecture. It is based on dual MCUs and FPGA, aiming at solving the problem of closure in general robot controllers. This open controller uses FPGA as a bridge, through which two MCUs realize data-sharing and collaborative control. The main MCU partly open to the users and the auxiliary MCU fully open. Finally, the performance of the controller is tested through the linear interpolation trajectory positioning accuracy experiment on the Kawasaki RA10N robot, and the result shows that it can satisfy the design requirements.

14:25 – 14:40
PDF [104]

SuAT3.4: Modular Design and Actuation System Comparison for Underactuated Tendon-Driven Soft Anthropomorphic Robotic Finger
Hongliang Ren

The objective of this project is to propose an alternative design for hyper-redundant, tendon-driven, discrete-joint manipulators which allows for independent removal of intermediate modules, as well as to conduct a comparative study between two alternative forms of tendon-driven actuation systems, twisted string actuation and spooling actuation. Hyper-redundant discrete-joint manipulators have individual modules connected in series and when paired with a tendon-driven actuation system, intermediate modules cannot be isolated. This lack of modularity limits the ability to quickly replace intermediate modules without the need to disassemble the entire system. Efficacy of modularity is measured by the fastest time required to remove and add intermediate modules to a series of modules. Comparison between maximum force generated by twisted string actuation and spooling actuation is done. The effects of different materials and diameter on the maximum force generated for twisted string actuation are also tested. Subjects are able to add and remove intermediate modules from the proposed design faster than a benchmark design. Twisted string actuation tests suggest that it is able to generate a larger force as compared to spooling actuation. Different string material and diameter are also shown to affect the maximum force generated. If needed, further research should be done to better quantify factors which contribute to failure of the string in twisted string actuation.

14:40 – 14:55 **SuAT3.5:** Pose interpolation for industrial manipulators under manual guidance
PDF [209] *Sreekanth Kana, Dhanya Menoth Mohan, Gia-Hoang Phan and Domenico Campolo*

Collaboration (HRC) has shown great promise across a wide range of disciplines. The role of robots often ranges from being an assistant to even a co-worker. This paper discusses a collaborative framework, whereby a robot assists the human in achieving smooth tool pose transitions during the course of a tooling task. The human operator manually teaches the robot a set of orientations at specific key locations on the workpiece, prior to the commencement of the task. Subsequently, a spatial field of virtual frames is generated through Inverse Distance Weighted interpolation, which in turn governs the tool orientation at each instance of robot motion. Afterward, a guided curve tracing task on a three-dimensional surface is performed to analyze the effectiveness of the approach.

14:55 – 15:10 **SuAT3.6:** Development of a Virtual Teaching Pendant System for Serial Robots based on ROS-I
PDF [268] *Luping Chen, Zhongqi Wei, Fei Zhao and Tao Tao*

The aim of this paper was to present a virtual teaching pendant system for serial industrial robots. Based on Robot Operating System Industrial (ROS-I), the virtual teaching pendant system we designed has the capacity for robot model establishment, direct and inverse kinematics manipulation, as well as motion planning. This virtual teaching pendant system not only contains the main teaching pendant functions but can drive any serial robots in both simulation and real-world. This paper will also highlight the many advantages of this virtual teaching pendant system which can be used as a good teaching tool to help students in understanding robotics. Several demonstrations are made to show the universality and functionality of the virtual teaching pendant system.

15:10 – 15:25 **SuAT3.7:** The Task-level Evaluation Model for a Flexible Assembly Task with an Industrial Dual-arm Robot
PDF [180] *Ching-Yen Weng and I-Ming Chen*

This paper is aimed to propose an evaluation model for a flexible assembly task with an industrial dual-arm robot. A simple peg-in-hole insertion process is initially realized by a Kawada Nextage Open dual-arm robot equipped with a vision system in a structured environment. Several assumptions are used to satisfy the scenario in practical

manufacturing, and various kinds of evaluation performance indices are introduced to analyze the task-level performance in a robotic assembly system with the development of an evaluation model based on CTMC for practitioners to assess the performance of the robotic assembly system. Finally, we implement the peg-in-hole task by means of two strategies respectively. The generated experimental results are combined with the evaluation model to verify the cost effectiveness for these two strategies.

Venue:	Pacific Hall 4A
Session:	**SuBT1:** Aerospace Control Systems and Applications I
Date/Time:	Sunday, 19 November 2017, 15:45 – 17:15
Chair:	Lei Liu / Hai Yuan

15:45 – 16:00

PDF [124]

SuBT1.1: Dynamics Analysis of a Missile Vehicle Considering the Pavement Roughness

Lixu Wang, Hongyu Tian, Xi Liang, Cheng Wei, Yang Zhao and Lijie Chen

In order to analyze the acceleration response of the connecting bolts on missiles during the missile vehicle maneuvering, a method to simulate the roughness of pavements via the power spectral density of pavements is proposed according to GB/T 7031-2005. A dynamical model of the missile vehicle is built by using "Magic Formula" and Lagrangian dynamics. The travelling process is simulated by Adams with different pavements generated by the method, and then acceleration of the prototype is calculated. As a result, acceleration increases while the roughness of pavements becomes worse. The vibration and the standard deviation of acceleration increase when the stiffness of the suspension system is magnified. The standard deviation of vertical acceleration of connecting bolts are calculated when suspension stiffness is within the range of 200N/mm-400N/mm and the corresponding empirical law is given, which is useful to estimate the approximate vertical accelerations at the centroids of the explosive bolts for different suspension's stiffness.

16:00 – 16:15

PDF [165]

SuBT1.2: Quadrotor attitude control based on nonlinear active disturbance rejection control

Wenya Zhou, Libo Qin, Long'En Li and Wenhui Jiang

The characteristics of non-linearity, strong coupling and vulnerability to external disturbances exist inherently in attitude dynamics system of quadrotor. In order to eliminate the influence of coupling during attitude channels and improve the anti-disturbance ability of controller, an attitude decoupling algorithm based on active disturbance rejection control (ADRC) is designed in this paper. By analyzing attitude dynamics equation, attitude coupling are divided into two parts: static coupling part and dynamic coupling part. A set of virtual control variables are introduced to decouple the static coupling. The dynamic coupling part is taken as the internal disturbance which is estimated by extended state observer (ESO) and compensated in the control law. Moreover, extended state observer can also estimate the external disturbances precisely. The simulation results show that comparing with PID controller, the ADRC controller has grateful performance in both decoupling control and anti-disturbance ability.

16:15 – 16:30

PDF [203]

SuBT1.3: Design and Robust Control of Space Debris Laser Removing Satellite

Hongjie Yang, Lei Liu, Yichen Li, Danqi He and Xinguo Li

This paper proposes a space debris removal strategy that use a satellite to relay ground-based laser to remove the 1~10cm debris of GEO orbit. The requirement receiving mirror and launching mirror on satellite has been designed, further, the natural frequency of satellite and the solar panel are obtained by finite element software. A robust controller is designed for attitude control of the proposed satellite, the attitude stability control simulation shows the elastic vibration of the solar panel can be inhibited. Finally, the control system of experiment satellite has be designed, and the attitude control experiment is validated.

16:30 – 16:45
PDF [190]

SuBT1.4: Rapid Development of Air Bearing Three-axis Stabilized Satellite
Hai Yun and Lei Liu

This paper proposed rapid development of an air bearing three-axis stabilized satellite system. In order to facilitate the centroid adjustment and instrument assembling, a symmetrical structural platform is designed. Taking into account the payload and motion range, the super-hemispherical air bearing is designed. The three orthogonal flywheel modules have been developed for attitude control. Regarding the fast centroid adjustment, the three orthogonal screw mass adjustment mechanism is designed, and the adjustment method is given to realize the requirement of gravity eccentric interference torque less than 0.01Nm. Finally, the PD control law is tuned to realize the three-axis attitude stability control, and the control accuracy is 0.5。.

16:45 – 17:00
PDF [141]

SuBT1.5: Switching Logic Design for Divert and Attitude Control System of Exoatmospheric Kill Vehicle
Jingwei Xie and Wanchun Chen

In this paper a six degree-of-freedom (DOF) model of exoatmospheric kill vehicle (EKV) is established, which employs four divert thrusters and six attitude control nozzles to execute kinetic interception. Due to the constraint on visual field of strapdown infrared seeker, we prefer to describe the motion of ballistic warhead in EKV's body coordinates. So the relative dynamic equations between interceptor and target are derived for convenience. Then based on proportional navigation guidance (PNG) law and quasi-sliding mode method, a switching logic for divert and attitude control system (DACS) is developed. To ensure celerity and accuracy and meanwhile, avoid oscillation in the system, the method of dead zone is introduced into our logic design. In the end of study, a numerical simulation including EKV and ballistic target is made to test the performance of DACS. The simulation results are discussed and the analyses of ignition instruction and line-of-sight (LOS) angle are also given. The interception of no-maneuvering target is accurate with little consumption of propellant. But the EKV fails to hit the spiral maneuvering target unless optimal weave guidance (OWG) law is employed.

17:00 – 17:15
PDF [285]

SuBT1.6: A New Method of Multi-Target Threat Assessment for Air Combat
Yang Yang Gao, Min Jian Yu and Zi Bo Lin Wang

In order to evaluate the threat level of the fighter in the air combat more Accurately, a new method of evaluating the multi-target threat level is proposed. The method uses the cloud model theory to describe the qualitative and quantitative concept of battlefield situation. The distance entropy theory is used to determine the objective weight of the target attributes, and the weights are applied to the TOPSIS method to research the air multi-target threat assessment. Finally, an example is given, showing that the method is reasonable and effective.

Venue:	Pacific Hall 4B
Session:	**SuBT2:** Vehicles and Navigation II
Date/Time:	Sunday, 19 November 2017, 15:45 – 17:15
Chair:	Yue Xiao / Shaohui Foong

15:45 – 16:00
PDF [109]

SuBT2.1: A robust global fast terminal sliding mode controller for quadrotor helicopters
Jiaxin Yuan, Wenhao Xu, Zhan Qiu and Fuxin Wang

This paper investigated a robust global fast terminal sliding mode control approach for quadrotor helicopters with time varying uncertainties. The controller adopts inner outer loop control structure. The inner loop is the attitude subsystem, while the outer loop is the position subsystem. Based on the global fast terminal sliding mode control theory, the position and attitude subsystems are designed respectively, and the intermediate command generated by position subsystem is passed to the attitude subsystem. The proposed control scheme is to achieve the fast, high precision and finite time control performance. Simulation results show that the proposed control strategy is effective and robust in the presence of time-varying uncertainties.

16:00 – 16:15
PDF [114]

SuBT2.2: Propulsion efficiency of flapping flight robots
Longfei Zhao, Yaoxing Shang and Zongxia Jiao

Flapping wing technologies have been successfully applied to robots either flying in the air or gliding through the water owing to the unique advantages of flapping flight under small Re conditions. Propulsion efficiency of flapping-twisting compound motion wings are analyzed in the present study. Actuator disc theory and undulating wave theory are utilized to model the wings' propulsion efficiency, and the present method is verified by a Lattice Boltzmann method(LBM) based code, on an 800mm wing-span virtual flapping wing model. Compared with conventional methods including unsteady method, vortex lattice method or numerical method, the present method is much simpler and relates basic design parameters of flapping wings directly to the efficiency output. In this way, the present method provides a macroscopic view towards propulsion mechanisms of flapping wings, and has the potential to greatly accelerates the process of flapping wing robots' first period design, which usually rely on experience or parameters adopted from flapping flight creatures.

16:15 – 16:30
PDF [122]

SuBT2.3: Task-Orientated Robot Teleoperation using Wearable IMUs
Qilong Yuan, Yee Seng Teoh, Qinghua Lu and I-Ming Chen

This paper introduces a robot teleoperation system using the human hand motion captured from IMU systems, and the evaluation of the performances based on user tests. In the system, with properly defined task scenarios and suitable initial hand posture for comfortable operation, the captured hand motion is mapped into the robot end-effector motion based on a simplified mapping function with adaptive parameters for different users. Experimental teleoperation testing on grasping tasks shows the efficiency of the system. Users can quickly adapt to the system and use such system for teleoperation with stable and smooth motion outputs. The testing also helps in addressing the directions to make improvements in developing such system in future.

16:30 – 16:45
PDF [127]

SuBT2.4: A new proposal for localization of omni-directional mobile robot by DM tag in indoor environment
Baolai Xu, Xuefeng Zhou, Taobo Cheng, Zerong Su and Junjun Wu

A conventional omni-directional mobile robot typically uses odometry as the localization technique that has the advantage of continuous positioning. However, odometry inevitably suffers from errors accumulating over time, because of wheel slippage, unequal wheels diameter and so on. Therefore, this paper proposes a relative localization algorithm to accurately locate the robot by fusing odometry and equidistant landmarks. In our work, DM tags deployed in a grid-like pattern on the ground are used as artificial landmarks to correct the odometry error by using Unscented Kalman filtering (UKF) fusion algorithm. All DM tags are the same in this work so that the damaged tags can be quickly replaced with new ones. This is very useful for the application in a large area. Experiments show that this approach can achieve good feasibility and higher localization precision than using only odometry.

16:45 – 17:00
PDF [232]

SuBT2.5: Localization of Indoor Robot based on Particle Filter with EKF Proposal Distribution
Yue Xiao, Yongsheng Ou and Wei Feng

The indoor localization of the mobile robot is an important problem. The laser sensor is commonly used in the localization of robot. However, a low-cost LIDAR usually leads to a poor localization result because of the sparse scan points. In face of this problem, map based particle filter localization in indoor environment is realized for the robot equipped with 2D LIDAR. The proposal distribution is obtained from fusing the motion model prior and the most recent measurement by Extended Kalman Filter (EKF). We analyzed the prior distribution and the EKF distribution and realized the particle filter localization on the robot. Experiments show this method is effective.

17:00 – 17:15
PDF [238]

SuBT2.6: Design and Development of Micro-Aerial Vehicle for Tree Inspections
Chee How Tan, Jake Tze Huan Goh, Wei Jun Ang, Jiong Le Lee, Ervine Shengwei Lin, Gim Song Soh and Shaohui Foong

This paper presents the design and development of a lightweight and low risk Micro-Aerial Vehicle (MAV) for tree inspections. The proposed MAV is utilised to make inspection process safer and more efficient by deploying the MAV to augment arborists with visual assessment of tree defects at high altitude. The needs of arborist and the environment that the MAV is operating is translated into design requirements that is incorporated into the MAV design. The composite mechanical frame of the MAV was designed and analysed using finite element analysis (FEA) in Solidworks, designed using the Tsai-Hill criterion. The MAV has a unique propeller guard to protect the spinning propellers from getting caught during flight in the tree canopy, as well as to extract aerodynamics gain from the ducted design. The theoretical aerodynamics gain over unducted propeller was analysed using momentum theory. The effects of the duct length and the number of spokes at the duct outlet on the thrust generated by the propeller was experimentally studied. The high-definition visual inspection system is driven by a compact and lightweight double-rocker mechanism synthesized using analytical approach for optimal transmission angle. The best performing ducted propeller guard design and mechanism design for the actuation of the visual inspection system was implemented on the MAV and achieved successful flight in an operational environment.

Venue:	Pacific Hall 5
Session:	**SuBT3:** Power, Communications and Networks
Date/Time:	Sunday, 19 November 2017, 15:45 – 17:15
Chair:	Jouni Mattila / Manuel de La Sen

15:45 – 16:00
PDF [155]

SuBT3.1: Research on WLAN Planning Problem Based on Optimization Models and Multi-Agent Algorithm
You Zheng, Tailong Shi, Xiaohuo Xu, Hongxing Yuan and Tuozhong Yao

Along with highly required quality of wireless communication, the deployment of Wireless Local Area Network (WLAN) has been attached more and more significance in the field of optimization, and numerous research works investigate the use of formal optimization techniques for WLAN planning. However, once facing the large scale deployment scenarios, these approaches may not effectively optimize them. The main contribution of the work presented in this paper is to describe a mathematical WLAN model and give a multi-agent optimization algorithm which is based on distributed artificial intelligence and has an ability to deploy the large scale WLAN.

16:00 – 16:15
PDF [156]

SuBT3.2: Energy Finite Element Analysis of Vibrating Thin Plates at High Frequency
Zhili Lin, Xiliang Chen and Bo Zhang

Energy Finite Element Analysis (EFEA) is developed to solve the problem of vibration plates at high frequency. The energy governing equations in the EFEA based on the space- and time-averaged energy density to represent the general vibration behavior are derived. In this paper, the derived energy equations are analogous to the tradition governing equations in Finite Element Analysis (FEA). Thus, the energy equations can be implemented numerically and applied to complicatedly vibrating structures. To verify the validity of the developed energy finite energy formulation, various energy flow methods are performed for transversely vibrating plates at various hysteresis damping loss factors and excitation frequencies. Finally, the EFEA solutions effectively represent the global variation of exact results, and some figures show that the present EFEA solutions are more analogous to the exact results than the traditional FEA solutions. Hence, the EFEA may be an optional energy flow method to analyze the high frequency problem of complex structures at high frequency.

16:15 – 16:30
PDF [131]

SuBT3.3: Power Management of Analgesic Equipment Based on STM32
Qiyin Deng, Jun Zhong, Yongfeng Liu and Yong Yu

Aiming at the high power consumption problem of analgesic pump, It is vital to have reasonable dynamically control of the low power mode of main chip STM32. Propose the software optimization program and power management of the equipment power, through the program, the equipment's operating current has a significant decline, thus extending the battery life extremely.

16:30 – 16:45
PDF [277]

SuBT3.4: The Signal Integrity design and simulation of Triple Modular Redundant (TMR) Computer
Pan Zheng, Qi Zheng, Liman Yang and Zhankui Zeng

This paper analyzes the problem of Signal Integrity in the design of high speed communication between modules of Triple Modular Redundant (TMR) computer, from the detrimental effect caused by Reflection and Simultaneous Switching Noise (SSN).And, the

simulation with the whole computer is tested and verified. Then, the design of TMR computer is improved by the simulation. This paper proposes solutions from the layout, circuit design and signal link, etc. And the solutions are tested and verified. Its results show that the improvement effect is obvious and improve the stability and reliability of the TMR computer and meet the needs of signal integrity for the high speed communication modules of Triple Modular Redundant (TMR) Computer.

16:45 – 17:00
PDF [105]

SuBT3.5: A culling switching parallel scheme for an SEIADR epidemic model
Manuel de La Sen, Raul Nistal, Santiago Alonso-Quesada and Asier Ibeas

This paper develops a parallel structure for an SEIADR epidemic model which consists of the subpopulations susceptible (S), exposed (E), symptomatic infectious (I), asymptomatic infectious (A), dead lying bodies (D) and recovered by immunity (R). The epidemic model has eventually three controls: vaccination, treatment and impulsive culling on the infective lying bodies. The proposed supervised scheme consists of several alternative corpses culling controller parameterizations in a parallel disposal jointly with a switching scheme which chooses the active one to be in operation on each current inter-switching time interval. The supervisory scheme decides about switching from an impulsive culling action to another one when a predefined supervised loss function of a new candidate has improved along the last tested inter-switching time interval.

17:00 – 17:15
PDF [125]

SuBT3.6: Control of Battery-powered NCSs with Channel Assignment and Power Allocation
Liyuan Wang and Wei Yue

This paper investigates the simultaneous stabilization of a collection of battery-powered systems with limited bandwidth and power resources. Each time the channel can only accommodate one plant for communication and each sensor can transmit data to the remote controller using high power for limited times. Based on the average dwell time technique, sufficient conditions on the exponential mean square stability of a single plant are given first. Then, a set of schedulable conditions is obtained for periodic scheduling policy based on the simultaneous stability analysis. Finally, a new framework for channel scheduling, power allocation and stabilizing control is constructed, which can guarantee a desired decay rate for each plant and minimal energy consumption for the group of plants. The effectiveness of the methodology is demonstrated with numerical simulations.

Day 2: 20 November 2017

AM Sessions

Venue:	Pacific Hall 4A
Session:	**MoAT1:** Biomechatronics I
Date/Time:	Monday, 20 November 2017, 08:30 – 10:00
Chair:	Hwan Ing Hee / Domenico Campolo
08:30 – 08:45 **PDF** [224]	**MoAT1.1:** Joint stiffness and mechanical impedance estimation during a tooling task *Gia-Hoang Phan, Clint Hansen and Domenico Campolo* Evaluation of human wrist stiffness while performing the tooling task plays an important role in translating into planning strategies for robot programming and control. This paper describes an algorithm for estimating human wrist stiffness during the tooling task using the instrumented tool. The experimental validation is performed by one DOF robot wrist together with an impedance control strategy.
08:45 – 09:00 **PDF** [195]	**MoAT1.2:** The sEMG characteristics of human upper limb during circle drawing on BC-EULRR system *Shutao Zhang, Guokun Zuo, Changcheng Shi, Jialin Xu, Xiangxing Liu, Jingjing Gao and Guoping Li* The most of patients who have suffered a stroke experience upper limb impairments, making stroke the leading cause of adult disability. Robot-assisted task-specific training, which is an effective method to improve the performance of action, focuses on learning or relearning a motor skill. Circle-drawing with a robot together are not only beneficial as an adjunct to task-specific training and strengthening upper limb muscles, but also a part of the clinical evaluation protocols. In order to let the robot provide individuals effective prescriptions of rehabilitation settings to achieve precision rehabilitation for post-stroke patients, the acquirement and analysis of characteristics of upper limb muscles during the robot-assisted circle drawing rehabilitation training are most important. The surface EMG is presented and applied to characterize the development of upper limb muscles during motor rehabilitation. The experiment is carried out under the condition of normal people is guided by rehabilitation robot drive upper limb drawing accurate circle in passive mode. It found that the muscle tension of different upper limb muscles changed regularly during circle drawing with the rehabilitation robot guidance, which provides important theoretical basis for making more effective training plans and steers upper limb motor function for stroke rehabilitation.
09:00 – 09:15 **PDF** [280]	**MoAT1.3:** Extracting Error-related Potentials from Motion Imagination EEG in Noninvasive Brain-Computer Interface *Yue Zhang, Weihai Chen, Jianbin Zhang and Jianhua Wang* Brain-computer interface is a communication system for controlling a device, e.g. computer, wheelchair or robot, by human intensions, which does not depend on the brains normal output pathways of peripheral nerves and muscles but relies on the detectable signals representing responsive or intentional brain activities. This study studied the BCI system that was based on the left-right hand motion imagination (MI) from the offline analysis and online application. First of all, we designed a MI brain-computer interface (BCI)

experimental paradigm with visual cues, and collected the EEG signal of the left-right hand MI in offline experiment, of which the average classification accuracy was 69.14% after analyzed. Secondly, five able-bodied subjects executed two online sessions individually, of which the average classification accuracy was 64.5% and 66.2%, respectively. The characteristics of features are mainly in the Mu (8-13Hz) and Beta (14-30Hz) frequency band with the channels of FC3, FC4, C3, C4, CP3 and CP4. Finally, we designed a new protocol to extract the error-related potentials (ErrPs). Furthermore, we also analyzed follow-up study plans that extract the ErrPs signal online in real-time used for cancelling the error command sent by BCI.

09:15 – 09:30
PDF [221]

MoAT1.4: Enhancing perioperative transfer of special needs children with THE I-MOVE
Hwan Ing Hee, Kiang Loong Ng, Manolo Sta Cruz, Aloysius Tan, Kavitha Raghavan and Haoyong Yu

Special needs children with neurodevelopment disorders are often uncooperative and disruptive during routine hospitalization processes such as initiation of anesthesia and transfer to operating table. These patients are often manually restrained and lifted onto the operating table by healthcare staff after they are anaesthetized, placing these children at risk of fall injuries and hospital staff at risk of back injuries and physical injuries inflicted by these patients. In this paper, we described a prototype robotics system with sensing and actuation systems for safe perioperative transport, transfer and procedures for uncooperative combative children to maximize safety for patients and healthcare workers and to enhance operating theatre efficiency and throughput.

09:30 – 09:45
PDF [222]

MoAT1.5: Finite Element Analysis of Femoral Mechanical Properties in MATLAB Environment
Monan Wang, Shufeng Wang and Chen Duan

Based on the finite element method and elastoplasticity theory, the femur biomechanical theory model and the femoral biomechanical experimental model which can reflect the nonuniform distribution and anisotropy of femur are established by using CT images. The finite element analysis of the model can be realized by MATLAB software. Based on the comparison of the finite element analysis results of the two models, the feasibility of the femoral biomechanical theory model to replace the femoral biomechanical experiment model was discussed.

09:45 – 10:00
PDF [149]

MoAT1.6: Walking trajectory generation for a 3D printing biped robot based on human natural gait and ZMP criteria
Ping Wang, Yabo Wang, He Huang and Feng Ru

With development of 3D printing technology, making a customized robot is more fast and easy. In order to adapted various walking patterns for the customized biped robot, mimic human gait is one of the solutions. In this paper, human natural gait is firstly captured by video system. The human body is modeled to use kinematic equations to find the joint angle from the captured trajectory. However, direct application of those captured joint angle data into the robot presents unnatural, poor balance. An improved walking trajectory algorithm is proposed based on the human natural gait and ZMP (zero moment point) criteria. The generated new gait trajectories are tested on the simulation model to get the stability of each joint movement and generate gait trajectory of the robot. Adapted walking pattern is successfully applied on the 3D printing biped robot.

Venue:	Pacific Hall 4B
Session:	**MoAT2:** Devices – Electromagnetic I
Date/Time:	Monday, 20 November 2017, 08:30 – 10:00
Chair:	Liang Yan / Jinhua Chen

08:30 – 08:45

PDF [115]

MoAT2.1: Design, analysis and experiments of novel short-stroke linear loading system based on axial-magnetized voice-coil motor for linear oscillating actuator

Tianyi Wang, Yuan Cao, Liang Yan and Zongxia Jiao

Linear oscillating actuator is a kind of electromagnetic device, providing high frequency short-stroke reciprocating motion directly without extra motion transfer mechanisms. It shows satisfactory efficiency and power density especially with high frequency and large load. However, due to its special motion forms, researches into driving and control of linear oscillating actuator under loaded states are seldom conducted because traditional loading methods, such as magnetic powder brake and weight loading, are not suitable for high-frequency linear bi-direction loading applications. In order to deal with this problem, a novel linear loading system based on voice-coil motor is proposed in this paper to facilitate comprehensive testing and control of linear oscillating actuators with load. To achieve fast response, low inertia and stable loading force, symmetrical axial-magnetized array is adopted among the various magnetic configuration solutions. Moreover, non-ferromagnetic and non-conductive mover is designed for both low inertia and eddy current suppression. For validation, magnetic circuit configuration is firstly analyzed and leads to the analytical model of flux density and thrust. Based on the model, detailed structure optimization is conducted to instruct prototype design. Finally, complete experiments of proposed loading system is presented, including static output and thermal distribution. And it is expected to provide a practical solution to similar linear loading applications.

08:45 – 09:00

PDF [168]

MoAT2.2: Ventilation System Design and Rotor Air Friction Loss of High-Speed Permanent Magnet Machines

Wei Liu, Jin-Hua Chen, Chi Zhang, Zhi-Qin Cui and Xuezhen Wang

Because of its advantages such as large power density, small size and high efficiency, high-speed machine has been widely used in aerospace, industrial production and other fields. However, it is easy to cause irreversible permanent magnet demagnetization because of high density and difficult heat dissipation. In view of the above problems, the fluid field simulations of two ventilation systems are carried out, and a detailed fluid field analysis is carried out for the better middle ventilation system. High-speed permanent magnet machine rotor surface speed is very fast, resulting in the friction of the air cannot be ignored. But its numerical value is related to many factors, such as machine speed, ventilation system, inlet wind velocity and surface roughness of the rotor. It is difficult to calculate accurately by analytic method. We simulated the 3D fluid model of rotor air friction loss and many factors influence on the high-speed permanent magnet machine is analyzed, and summarizes the corresponding high-speed permanent magnet machine rotor air friction loss law.

09:00 – 09:15

PDF [169]

MoAT2.3: Parametric Analysis of the Magnet Location Based on Straight-shape Internal Permanent Magnet Synchronous Motor

Wen-Hao Wu, Yun-De Zhu and Da-Guo Yu

For straight-shape magnet internal structure, air gap flux density and cogging torque are considerably affected by installation position of magnets under the premise of the same

amount of the permanent magnet involved. An analytical mathematical model is established based on energy method and magnetic path analysis method, for illustrating mathematical correlation of cogging torque and the magnets position. Cogging torque parameter has been swept with respect to installation position of magnets utilizing motor model. Based on the modular structure, the modules with different materials are set up to avoid local saturation around the root region of stator tooth and weaken the cogging torque. The validation of mathematical expression and the effectiveness of modular structure are proved by finite element analysis.

09:15 – 09:30 **MoAT2.4:** Analytical Calculation of Air-Gap Magnetic Field of Surface-Mounted Permanent Magnet Motor with Bread-loaf Magnets

PDF [172] *Zengqiang Ai, Jinhua Chen, Youyong Liao, Chi Zhang and Jianke Du*

This paper develops an analytical model for predicting the air-gap magnetic field of surface-mounted permanent magnet motor with Bread-Loaf magnets considering the slotting effect. The Bread-Loaf magnets are finitely segmented into magnet pieces of regular shape. The radial and tangential components of the no-load flux density in a slotless air gap is obtained by the superposition of the magnetic field due to each segment. Then the conformal transformation method is presented to take into account the effect of slotting. The correctness of the analytical model is verified with two-dimensional finite-element method and experiment.

09:30 – 09:45 **MoAT2.5:** Parameter Analysis of a Novel Planar Motor with Dual-layer Magnetic Array

PDF [263] *Liang Yan, Zengliang Ping and Zongxia Jiao*

In the manufacturing processes, the requirements for mechanical equipment are getting higher and higher. The precision mechanical equipment usually require the following characteristics, multiple degree of freedom, high precision, high frequency response, fine output characteristics, high force density, and so on. The traditional ball-screw structures has gradually begun to not meet the needs of precision machining. Now the direct-driving moving platform, also called planar motor, attracts wide attention. But the technology for designing and manufacturing the planar motor is not mature enough, and the output characteristics, for example, output force and stroke, are not satisfactory enough. In the paper, a new conceptual design of planar motor by means of using double-layer twodimensional magnetic arrays is proposed. It can extend its stroke by connecting multiple planar motors together, increase the output force density, and suppress the fluctuation of the output force."

09:45 – 10:00 **MoAT2.6:** Cogging Torque Reduction in External-rotor Permanent Magnet Torque Motor Based on Different Shape of Magnet

PDF [167] *Zhen Li, Jinhua Chen, Chi Zhang, Liang Liu and Xuezhen Wang*

The external-rotor permanent magnet torque motor is widely used in electric vehicles and mobile robots. In order to improve its working accuracy, the cogging torque needs to be reduced. Cogging torque results from the interaction of permanent magnet magnetomotive force harmonics and air-gap permeance harmonics due to slotting. In this paper, the finite element analysis (FEA) has been conducted on the external-rotor surface-mounted permanent magnet motor. Cogging torque can be reduced by optimizing the shape of the permanent magnet (PM) according to the theoretical analysis. And three types of PM pole shape are adopt to reduce the cogging torque. By optimizing the dimension parameters of PMs, each of these three shapes can reduce the cogging torque effectively.

Venue:	Pacific Hall 5

Session:	**MoAT3:** Identification and Control I
Date/Time:	Monday, 20 November 2017, 08:30 – 10:00
Chair:	Liman Yang / Silu Chen
08:30 – 08:45 **PDF** [108]	**MoAT3.1:** Lyapunov-based Feedback Control of Two-level Stochastic Open Quantum Systems *Shahid Qamar, Shuang Cong and Bilal Riaz* In this paper, a Lyapunov-based feedback control (LFC) is proposed for the state transfer of a two-level stochastic quantum system. The quantum state is described in the Cartesian coordinate system. An exponential function is selected as the Lyapunov function, the Lyapunov-based feedback control strategy is designed according to the stochastic Lyapunov stability theorem. Numerical simulations results show that the proposed LFC strategy has the ability to transfer the stochastic system from any initial mixed state to the desired eigenstate, and the LFC has high convergence rate and high state transfer fidelity.
08:45 – 09:00 **PDF** [164]	**MoAT3.2:** Optimal Coordinated Planning Strategy for Space Robots Grasping Targets *Xin Zhang, Jinguo Liu and Jindong Liu* The task of capturing a space target using a space robot carrying robotic manipulators can be divided into two phases: controlling the robot to reach a desired berth position near the floating target, and manipulating the manipulator to grasp the target. Most of the existing planning strategies only focus on a point-to-point trajectory planning of the manipulator to ensure the end-effector to reach a desired pose, while the berth position is usually set manually. In this paper, we propose an optimal coordinated planning strategy for space robots to grasp targets. Both the manipulator's joint trajectories and the robot's berth position are considered to autonomously accomplish the coordinated planning of the end-effector and the robot base. From the perspective of the task-space constraints, the manipulator is first planned to satisfy the attitude constraints of the end-effector and base, and then the berth position is planned to meet the end-effector's position. A Modified Generalized Jacobian Matrix (MGJM) is proposed to describe the velocity mapping from the joint space to the attitude of the end effector and the base. Based on the MGJM and Particle Swarm Optimization [18] (PSO), the whole planning task is turned to optimize the joint trajectories and the berth position. Simulated experiments have verified that the proposed planning strategy can successfully automate the two phases of a space robot to grasp target in the space.
09:00 – 09:15 **PDF** [197]	**MoAT3.3:** A Direct-Drive SCARA Robot for Wafer&Ceramic-Substrate Handling Based on Visual Servoing *Yunbo He, Chang Zhang, Wentao Ye, Zuoxiong He, Xin Chen, Jian Gao, Kai Zhang, Zhijun Yang, Xun Chen, Yun Chen and Hui Tang* Abstract—In this paper, a 4-DOF (Degrees of Freedom) direct-drive SCARA (Selective Compliant Assembly Robot Arm) robot is designed for wafer & ceramic-substrate handing purpose. In order to improve the flexibility of the whole wafer & ceramic-substrate handling system, we abandon the traditional aligner which can only achieve accurate positioning of the wafer and for ceramic-substrate is powerless, but introduce the visual servoing control strategy to excellent achieve the purpose of rapid and accurate aligning of the wafer & ceramic-substrate. In view of the structural characteristics of SCARA robot, we adopted the XY/Z-Partitioned IBVS scheme, which realized the control decoupling of x-, y-axis and z-axis. The reliability of visual servoing control strategy is verified by simulation and the physical

prototype of the SCARA robot. Performance meets with the requirements in the wafer&ceramic-substrate handling process.

09:15 – 09:30

PDF [274]

MoAT3.4: A Strategy of Network Bandwidth Scheduling based on Time Window Partition for Spacecraft Platform

Langfu Cui, Liman Yang, Xinqiang Yi and Qi Zheng

Future spacecrafts have characteristics of high mobility, load diversity and so on. The platform network system carries most of the data exchange tasks. With the diversity demands of system complexity and task load, it is necessary to carry out reasonable network planning. In order to meet the scheduling requirements and system stability, we analyze the multi-task information flow model of spacecraft and design the strategy of network bandwidth scheduling based on time window partition. At last, the software Matlab is used to simulate the scheduling strategy. The simulation results show that this scheduling strategy can meet the scheduling requirements and system stability.

09:30 – 09:45

PDF [267]

MoAT3.5: LQR Lateral-Directional Control Law Design for Distributed Propulsion Layout Flying Wing

Baoxu Liu and Zongxia Jiao

Flying Wing Layout aircraft has canceled the horizontal tail and Vertical Tail, using a redundant multi control-surface configuration scheme. Usually, such aircrafts that use large angle of the drag rudder to achieve its yaw operation, such as B-2, have a poor handling performance. And due to the existence of operational coupling, the hybrid control law needs to be designed with the rudder and the aileron. In this paper, we proposed a new type of distributed propulsion flying-wing unmanned aerial vehicle (UAV) scheme, and carried out its dynamic modeling and lateral-directional navigation decoupling. We analyzed the stability of the flying wing according to the state equation, and then designed and simulated the linear quadratic regulator (LQR) control law on this vehicle. The simulation results showed that compared with the common flying wing which own cracked drag rudder, the control effect of LQR controller distributed wing is improved and the operation quality is significantly increased.

09:45 – 10:00

PDF [264]

MoAT3.6: Linear Motor Tracking Control Based on Adaptive Robust Control and Extended State Observer

Liang Yan, Hongkai Qiao, Zongxia Jiao, Zihao Duan, Tianyi Wang and Ran Chen

Trajectory tracking control for linear oscillating motor is critical to improve the performance of linear electro-hydrostatic actuator (LEHA). However, both structured uncertainties (i.e., parametric uncertainties) and unstructured uncertainties (i.e., unmodeled dynamics, external disturbances, nonlinear friction) exist in LEHA may severely deteriorate the control performance of the system. In this paper, a control strategy which integrates adaptive robust control (ARC) and extended state observer (ESO) together is proposed to handle both structured and unstructured uncertainties. The proposed control strategy takes the advantages of ARC and ESO, which nullifies the disadvantages of ARC and ESO as well, guarantees accurate high-frequency trajectory tracking performance. In addition, a second-order system model is established by adapting dipole cancellation method and dominant pole theory before the design procedure of the controller. The simulation results are presented to verify the effectiveness and the achievable excellent performance of the proposed control strategy.

Venue:	Pacific Hall 4A
Session:	**MoBT1:** Medical Robotics
Date/Time:	Monday, 20 November 2017, 10:20 – 11:50
Chair:	Weihai Chen / Hongliang Ren

10:20 – 10:35
PDF [147]

MoBT1.1: Mechanism Design of the Minimally Invasive Vascular Interventional Surgery Robot System
Haiyang Liu, Hongbo Wang, Xue Yang, Zhennan Jin, Qiang Wang and Shanshan Li

A novel minimally invasive vascular interventional surgery robot system is proposed and manufactured. The system includes a positioning arm, a tube mechanical device and its manipulation device. In order to realize the simple and reliable space location and intuitive operation of the tube feeding mechanism, a new positioning mechanical arm is designed for the invasive vascular interventional surgery. A passive structure is adopted for the positioning arm, and a new scheme is adopted for the joint locking. The normal and inverse kinematics of the manipulator is calculated and the working space is simulated. The tube feeding mechanism realizes the axial feed of the catheter through a pair of reverse rotating rollers , and the rotation of the tube feeding machine along its own axis is realized by a unique gear drive mechanism, in addition the rotation of the catheter is realized. The separation of the tube feeding mechanical and its manipulation device allow that doctors do operations outside the operation room to protect themselves from radiation. Moreover, the system can realize force feedback which can help the operator to have force telepresence and to increase the sense of reality and immersion.

10:35 – 10:50
PDF [236]

MoBT1.2: Design and Control of a 4-DOF Cable-Driven Arm Rehabilitation Robot（CARR-4）
Zhongyi Li, Weihai Chen, Jianbin Zhang and Shaoping Bai

Robotic rehabilitation devices for patients with motor dysfunction can provide effective rehabilitation training. In this paper, a 4 degree-of-freedom cable-driven arm rehabilitation robot (CARR-4) and its controller have been proposed for shoulder and elbow rehabilitation training. The exoskeleton of CARR-4 consists of a 3-DOF shoulder module and a 1-DOF elbow module, and each of them can be controlled independently. Moreover, a mechanical design for a comforta-ble human-robot physical interface is considered. The control¬ler is primarily based on a robust adaptive iterative learning control （ILC） algorithm, which aids in compensating the model uncertainties and external dis¬turbance, improving the tracking performance. Through simu¬lations, the proposed controller is evaluated to satisfy the func¬tion requirement. Preliminary experiments are conducted on the prototype of CARR-4 for a repetitive task, which show the tracking errors are successfully improved.

10:50 – 11:05
PDF [279]

MoBT1.3: EEG-Based Brain-controlled Lower Extremity Exoskeleton Rehabilitation Robot
Gaojie Yu, Jianhua Wang, Weihai Chen and Jianbin Zhang

Brain-computer interfaces (BCIs), based on electroencephalography (EEG), have been proved to play an important role in motor rehabilitation, motor replacement, prosthesis control, and assistive technologies. BCIs can classify EEG signals and translate the brain activities into useful commands for external devices. This paper presents a brain-controlled lower extremity exoskeleton rehabilitation robot with a motor-imagery (MI)-based BCI to enhance active rehabilitation participation. Four healthy individuals performed MI tasks of left and right hand movements to control the speed of gait training. The proposed paradigm could be further implemented by adding motor tasks and promoting MI classification

accuracy.

11:05 – 11:20
PDF [103]

MoBT1.4: Creation of Statistical Atlas of Nasal Cavity from Computed Tomography Scans
Hongliang Ren

A statistical atlas is created based on the average and variations of a set of data. Statistical atlases are found to be able to provide reference navigation models for the nasal cavity. An innovative method of constructing a statistical atlas that requires a short amount of time to execute, yet having a relatively high accuracy has been developed. This study examines the existing approaches to construct a statistical atlas of the human nasal cavity, as well as the suggested improvements. A statistical atlas that focuses specifically on the pathway from the nostrils to the nasopharynx has been created. The shape variations of this pathway can also be observed from the statistical atlas. For the purpose of this study, 47 sets of patient data have been analyzed. In the future, two separate statistical atlases for the different genders can be created.

11:20 – 11:35
PDF [134]

MoBT1.5: An AR System to Motivate the Trainer during the Robot-Assisted Rehabilitation
Yuyao Liu, Ronglei Sun and Fusen Zhang

People who suffer from motor disabilities resulting from stroke have trouble with their daily life and mental state. The recovery of limb function is an essential demand to improve the self-care ability of the patients. Physical rehabilitation is the mostly used treatment. To free the therapy from high-intensity repetitive work rehabilitation robots provide alternetive method. However, due to the absence of therapies, it’s hard for patients to take the initiative to participate in exercise. The effect of rehabilitation training is greatly reduced. In this paper, a virtual therapist is built in AR environment, in which the trainer can see that the virtual therapist assists and interacts with the trainer in the exercise of rehabilitation, as if there were a real therapist around. Through this new technique, it alleviates the fear and boredom of the trainer. And more importantly, it enhances the role of the patient's subjective initiative so as to obtain a better training effect.

11:35 – 11:50
PDF [182]

MoBT1.6: Design of Node Controller for Wireless Monitoring System of Central Air Conditioner
Zhi-Yuan Weng, Zhigang Weng, Jie Fang, Gang Zhang and Ying Cheng

Central air conditioning is one of the very important and common equipment in intelligent building. In order to make the air conditioning system operate in an efficient and energy-saving state, the central air conditioning intelligent control system has studied based on wireless sensor network (WSN). The node controller is the core component of the central air conditioning control system. It realizes the control of the terminal equipment and the collection of the signals, and the wireless communication with the routing nodes. In this paper, the hardware circuit and software design of the note controller is proposed, and produces a prototype. The wireless real-time monitoring and control of the air conditioning system is realized, and the experimental results on the prototype show that the system runs stably.

Venue:	Pacific Hall 4B
Session:	**MoBT2:** Devices – Thermo and Hydraulic
Date/Time:	Monday, 20 November 2017, 10:20 – 11:50
Chair:	Shunan Li / Silu Chen

10:20 – 10:35

PDF [269]

MoBT2.1: A High accuracy hydraulic pressing actuation system for superplasticity forming equipment

Yufeng Qu, Bing Li, Shuai Wu, Zongxia Jiao, Hong Xiao and Xuefei Liu

The hydraulic pressing system is a major part of the superplastic forming equipment, which is used to moving and pressing modules. It requires to move the module quickly during opening or closing module chamber for saving heat energy, and also requires high accuracy pressing force control during superplastic blow forming process. Therefore, it usually requires a high flow rate and high frequency band width servo valve. But for servo valve, the band width is usually decreased when the flow rate becomes large. Meanwhile, high flow rate servo valve is very high cost. Indeed, it also very difficult to achieve high accuracy loading control for high flow rate servo since it is a static condition and the required flow rate is very small, which is smaller than to the resolution ratio of the servo valve. The proportional valve is low cost but it usually can not meet high accuracy pressure loading control since it has dead zone and hysteresis. This paper presents a new hybrid control scheme which using a high flow rate proportional valve combine with a small flow rate servo to control the pressing cylinder. The high flow rate proportional valve is used for motion control which requires of high flow rate and low accuracy, and the small flow servo valve to achieve high accuracy pressing load control while control accuracy is the most important. In the present study, the feasibility and the control algorithm is studied by AMEsim. The simulation results illustrate that the proposed scheme can meet the requirements of the requirement of the forming system.

10:35 – 10:50

PDF [198]

Investigation the Load Matching of Direct Pressure Valve Controlled Variable Mechanism of Axial Variable Piston Pump

Shunan Li, Yaoxing Shang, Shuai Wu, Yan Zhou and Zongxia Jiao

In order to improve the control performance of loading sense pump controlled system, a direct pressure valve is proposed in the present study to control the displacement actively. The valve is utilized to control the pressure feedback to the variable mechanism. The direct pressure valve can keep the advantage of high efficiency of loading sense system and high dynamic performance of constant pump simultaneously. The design of the structure of direct pressure valve is presented. Then, the load matching of the variable mechanism with the valve is studied. The design parameters are optimized. The simulation results indicate that direct pressure control valve is suitable for the system.

10:50 – 11:05

PDF [242]

MoBT2.2: A Multi-fault Diagnosis Strategy of Electro-Hydraulic Servo Actuation System based on Extended Kalman Filter

Xingjian Wang, Siru Lin, Shaoping Wang, Jian Shi and Chao Zhang

Electro-hydraulic servo actuation system is a mechanical, electrical and hydraulic mixing complex system. If it can't be repaired for a long time, it is necessary to consider the possibility of occurrence of multiple faults. Considering this possibility, this paper presents an extended Kalman filter (EKF) based method for multiple faults diagnosis. Through analysing the failure modes and mechanism of the electro-hydraulic servo actuation system and modelling selected typical failure modes, the relationship between the key parameters

of the system and the faults is obtained. The extended Kalman filter which is a commonly used algorithm for estimating parameters is used to on-line fault diagnosis. Then use the extended Kalman filter to diagnose potential faults. The simulation results show that the multi-fault diagnosis method based on extended Kalman filter is effective for multi-fault diagnosis of electro-hydraulic servo actuation system.

11:05 – 11:20

PDF [170]

MoBT2.3: Adaptive Backlash Inverse Augmented Virtual Decomposition Control of a Hydraulic Manipulator

Adeyemi Adeleke and Jouni Mattila

In addition to the inherent strong nonlinearities associated with hydraulic systems, the use of mechanical drives (gears) in hydraulic applications (e.g., in hydraulic rotary actuators) introduces additional nonlinearities in the form of backlash. Thus, confronting these traditional hydraulic non-linearities as well as the non-smooth backlash nonlinearity requires special considerations. This work designs a virtual decomposition control (VDC) controller, a subsytems-based nonlinear model-based controller, to combat the heavy hydraulic non-linearities in a hydraulic manipulator and effectively control it. For the first time, a VDC controller is designed to compensate for a non-smooth nonlinearity (backlash), which has never been modelled in the dynamic equations of all existing VDC works. While it is not presented herein, stability of the resulting controller can be mathematically proven based on the L_2 and 〖 L〗_∞ Lebesgue spaces. Obtained experimental results indicated the capability of the combined VDC algorithm and the adaptive backlash inverse scheme improves system's position tracking performance compared to the traditional Proportional-Integral-Derivative (PID) controller.

11:20 – 11:35

PDF [201]

MoBT2.4: Simulation about contamination influence of hot-film flow sensor on measurement accuracy

Yongxi Shen, Zhongsheng Sun, Changrong Yuan and Xiaoning Li

To research the contamination influence of hot-film air flow sensor on measurement accuracy, an analytical expression of temperature difference between two temperature sensing resistors is derived. The reason of the output variation of hot-film sensor is analyzed. The finite element model of contamination is built based on the deposited contamination distribution and its thickness. The influences of contamination thickness on temperature difference are analyzed on the condition of different velocities. As a result, the temperature difference between the upstream and downstream temperature sensing resistors decreases with the increase of contamination thickness. The relationship of output value, flow rate, and the contamination thickness is calculated by the analytical model. The results show it can cause a 68.15% error of measurement when the input flow velocity is 8m/s and the contamination thickness is 50μm.

11:35 – 11:50

PDF [266]

MoBT2.5: Temperature Uniformity Control Based on Thermal Resistance Network Model

Chongyang Yang, Wu Shuai, Yufeng Qu and Zongxia Jiao

Superplastic forming equipment completes the forming process making use of the excellent ductility of some metal (Ti2AlNb) in the ultra-high temperature, in which the temperature control is extremely important. A thermal resistance network model is established in Modelica in order to control the temperature uniformity and stability, and a simulation model of numerical analysis is established in ANSYS according to the actual engineering parameters. The temperature distribution of the two models is consistent under the same boundary condition, which verified the rationality and accuracy of the Modelica model. The temperature field of the superplastic forming equipment performs stably through the PID controller based on the Modelica model. After the temperature of the thermal resistance network model is analyzed, the reasonable temperature control instruction is generated by

decoupling, which makes the internal temperature distribution of the forming equipment uniform.

Venue:	Pacific Hall 5
Session:	**MoBT3:** Identification and Control II
Date/Time:	Monday, 20 November 2017, 10:20 – 11:50
Chair:	Jouni Mattila / Guilin Yang

10:20 – 10:35
PDF [110]

MoBT3.1: A New Interpretation of Adjoint Method in Linear Time-Varying System Analysis
Tailong He and Wanchun Chen

In this paper, the adjoint of linear time-varying (LTV) system is given in general state-space form. By using the essential relationship between LTV system and its adjoint, the "error budget", "general one run" and "special one run" interpretations of adjoint simulation are achieved in a new way. Moreover, the adjoint method in covariance analysis is presented. As an example, the performance analysis of a missile guidance system is performed by both covariance analysis and adjoint simulation, to illustrate the superiority of the adjoint simulation technique.

10:35 – 10:50
PDF [132]

MoBT3.2: A fault detection scheme for airship using dynamic principle components analysis with noise canceling based on Kalman filter
Chang Xiao, Weixiang Zhou, Pingfang Zhou, Yueying Wang and Dengping Duan

Dynamic Principle Components Analysis (DPCA) is a well-known technique for dynamic system fault detection. Similar to PCA, it computes a "standard space" with time-dependent average data and then uses a series of residual functions to judge whether a new state vector deviates from the normal space. What makes it superior over normal static PCA is the consideration of historical data and system input data. In this paper, we consider an airship fault detection method using DPCA. Additionally, a scheme based on Kalman filter is proposed to lower the influence of sensor noise. Simulation under DPCA and comparing results under PCA illustrate the effectiveness of the method.

10:50 – 11:05
PDF [138]

MoBT3.3: Aircraft cabin thermal control strategy based on adaptive temperature and thermal sensation
Dong Liu, Liping Pang, Yunpeng Chen and Yue Zhou

An Environment Control System (ECS) in civil aircraft will control the cabin thermal environment with constant temperature control strategy. However, the passenger dress, heat loads will change with the flight process. This constant control strategy cannot satisfy these dynamic requirements and faces the challenge. An aircraft cabin thermal control strategy based on adaptive temperature and thermal sensation evaluation is presented in this paper to solve this question. The new thermal control strategy includes initial and accurate control strategies, which individually control the thermal environment. For the night flight mode, the initial control strategy with a constant supply air temperature is used to control the cabin thermal environment according to the adaptive temperature. For the day time, the accurate control strategy with a dynamic supply air temperature is used to control the cabin thermal environment according to the thermal sensation of passenger. This new control strategy can ensure passengers in the aircraft cabin to have a comfortable thermal sensation under different flight times and seasons.

11:05 – 11:20
PDF [142]

MoBT3.4: Nonlinear full-model-based controller for unactuated joints in vertical plane
Pauli Mustalahti and Jouni Mattila

Articulated multiple degrees-of-freedom (DOF) hydraulic manipulators are used in many

industry tasks. These hydraulic manipulators can be used to move heavy loads, such as logs and containers. The grasping tool of these manipulators is often connected at the tip of the manipulator by using unactuated revolute joints, which are not directly controllable. Currently, work performed efficiently by commercial hydraulic manipulators depends on the driver, and the automation level of these manipulators is relatively low. The Virtual Decomposition Control (VDC) is the nonlinear model-based control theory, which performs subsystem-based control design and stability analysis for complex multiple DOF redundant hydraulics manipulators. In this paper, we present a VDC approach-based nonlinear full model-based anti-sway controller for a redundant manipulator in vertical plane. The experimental results, with a redundant hydraulic manipulator, verify that the proposed anti-sway control efficiently damps load swaying in the vertical plane motions.

11:20 – 11:35 **MoBT3.5:** Bilateral Control of Teleoperation Manipulator Based on Virtual Force Aware Guidance

PDF [148] *Manlu Liu, Qiang Ling, Jing Zhang, Liang Xu, Jiangmei Zhang and Hua Zhang*

In order to improve the control efficiency and reliability of teleoperation robot, a master-slave teleoperation system based on virtual haptic control is designed. The system integrates the visual information of the slave ends from the teleoperation robot and the intelligent decision making mechanism of the operator. The virtual force is established by the artificial potential field method, and the real-time virtual force guidance of the operator is realized, so that the manipulator can control the slave manipulator efficiently. In order to verify the effectiveness of the proposed method, a bilateral control system is built by using PHANTOM force feedback device and Kinect image equipment. The experimental results show that the control system can achieve stable force guided control. Compared to sleep away operating system boot, the operator does not need to be adjusted from the end of manipulator pose repeatedly. The operation time can be shortened by more than 60%, significantly improve the efficiency of control, get better optimization from the end of the redundant path. The master-slave method satisfies the requirements of the control performance, and the control method is feasible and effective.

11:35 – 11:50 **MoBT3.6:** Positive Velocity Feedback Control of Flexure-based Actuator for Vibration Suppression

PDF [183] *Zhikun Cao, Chi Zhang, Qiang Liu, Hongyuan Lian, Guilin Yang and Silu Chen*

Nanopositioning Stages based on flexure supporting mechanism are commonly used in precision manufacturing system with the advantages of non-friction and high accuracy. But there is always a major challenge to restrain the vibrations result from flexible supporting structure. This paper presents a novel control strategy based on positive velocity feedback (PVF) designed for flexure-based actuator, which is driven by voice coil motor. A PVF controller is designed to reduce resonance peak by using the similar ideal with positive position feedback[1]. Meanwhile, more advantages can be obtained with the employment of proportional-integral (PI) controller in position loop. The experiment results validate that the PVF control strategy presented in this paper can restrain vibration in nanopositioning stages effectively, and reduce resonance peak in velocity loop by 2dB, and increase the bandwidth by more than 40Hz.

PM Sessions

Venue:	Pacific Hall 4A
Session:	**MoCT1:** Measurements and Estimation
Date/Time:	Monday, 20 November 2017, 13:40 – 15:45
Chair:	Wen Chen / Silu Chen
13:40 – 13:55 **PDF** [111]	**MoCT1.1:** Maneuvering Target Estimation for the Optimal Guidance Law of Intercepting Missiles *Yang Zhang, Fugui Li and Xinmin Wang* It is very challenging for missiles to precisely intercept maneuvering targets. The existing methods for designing guidance laws usually did not sufficiently take the maneuvering of targets into consideration. This study designed an extended Kalman filter to estimate the parameters of maneuvering targets based on the information measured by phased array radar seekers. Furthermore, an optimal guidance law was derived with the estimated parameters of a maneuvering target. Our proposed methods were simulated under typical intercept conditions. The simulation results demonstrated that the precise intercept can be achieved by our derived optimal guidance law with the maneuvering target state estimated by our designed extended Kalman filter.
13:55 – 14:10 **PDF** [117]	**MoCT1.2:** Noise Covariance Identification Using Autocovariance Least-Squares Technique for State Estimation of Quadrotor *Jingyun Wu, Guoliang Liu and Tao Huang* When estimating the state of a quadrotor, information about the noise, especially the noise covariances are necessary. In this paper, the autocovariance least-square (ALS) method is applied to identify the process and measurement noise covariance in the model of the quadrotor. The identified covariances are used in the EKF program to get the filtered values of the state variables. The simulation results show that the filtered values are close to the true values.
14:10 – 14:40 **PDF** [140]	**MoCT1.3:** Preventive Maintenance Planning in a Unreliable Production Line with a Branch Buffer *Liyun Xu, Wei Wei, Yiping Chen and Aiping Li* In this paper, we consider a production line consisting of a main line, a feeder line and a branch buffer. The objective is to determine the optimal maintenance policy that will minimize the total system cost per unit time subject to a given system throughput level, buffer inventory and reliability of equipment. The optimal design problem is formulated as a multi-equipment integrated optimization model where the decision variables are reliability threshold and maintenance period of each machine. A heuristic algorithm is developed to solve the model. The proposed method is applied to a simulation case to show its advantage and necessity.
14:40 – 14:55 **PDF** [160]	**MoCT1.4:** Real-time Distance Query and Collision Avoidance for Point Clouds with Heavy-duty Redundant Manipulator *Tuomo Kivelä, Pauli Mustalahti and Jouni Mattila* This paper presents a real-time method for generating joint trajectories for redundant manipulators with collision avoidance capability. The coordinated motion control system of

the heavy-duty hydraulic manipulator resolves joint references so that a goal position can be reached in real-time without any collisions. The proposed method is able to detect and prevent different types of possible collisions, including self-collisions and collisions with obstacles. When the control system detects the risk of collision, the collision server searches the points where the collision is about to occur and calculates the shortest distance between the colliding objects. The collision server is used to retain static point clouds and to calculate the shortest distance between objects that are too close to each other. The point clouds on the server are kept up to date with the manipulators' joint sensors and laser scanner-based measurements. During coordinated motion control, the joint trajectories of the redundant manipulator are modified so that the collisions can be avoided, while at the same time, the trajectory of the end-effector maintains its initial trajectory if possible. Results are given for a 4-DOF redundant heavy-duty hydraulic manipulator to demonstrate the capability of this collision avoidance control system.

14:55 – 15:10

MoCT1.5: Rollover warning algorithm for vehicles based on dangerous speeds considering the suspension and dynamic characteristics

PDF [193]

Wei Zhang, Danhua Li, Weida Wang, Jian Wang and Haonan Peng

Rollover accidents involving buses adversely affect highway traffic and personal safety. The roll stability limit (RSL) of vehicles is analysed by investigating the roll dynamics and rollover mechanism of vehicles using a non-linear roll plane model. Taking the influence of suspension, the dynamic characteristic of the vehicle, and cross-fall, superelevation, or adverse camber on roads, on the RSL of vehicles, the threshold value of lateral acceleration for a rollover warning algorithm is acquired. The influence of the adhesion between tyres and the ground on the rollover warning threshold is analysed to distinguish it from false rollover alarms caused by sideslip. In addition, the research provides a method for calculating dangerous speeds. Then, the rollover warning algorithm based on those dangerous speeds is proposed, and verified in terms of accuracy and robustness by using a numerical simulation. The result shows that the proposed rollover warning algorithm can predict possible rollover accidents and is robust with respect to vehicle parameters and changes in working conditions. Brake control after a rollover warning indicates that rollover accidents can be effectively reduced by using the warning algorithm.

15:10 – 15:30

MoCT1.6: Monocular Semantic SLAM in Dynamic Street Scene Based on Multiple Object Tracking

PDF [239]

Wen Chen, Mu Fang, Yun-Hui Liu and Luyang Li

Semantic information has been agreed to be a key complement for more accurate SLAM or navigation and higherlevel behavior planning. In dynamic scene, it also has the potential to improve performance. In this paper, we combine monocular SLAM with multiple object tracking to obtain robust static semantic map in complicated environment. This system utilizes up-to-date CNN object detector to detect possible moving objects in current view. Without the features located in these objects, monocular SLAM get consecutive pose transformation between two adjacent frames, which help multiple object tracking. With these trackers, this system can filter out dynamic objects and retain static objects for further sematic data association and graph optimization. We evaluate our approaches on the popular KITTI dataset and high dynamic RobotCar dataset.

15:30 – 15:45

MoCT1.7: A Multi-feature Fusion Moving Target Recognition Method Based On Believability Regression Reasoning

PDF [292]

Xiaogang Tang, Sun'An Wang, Hongyu Di and Litian Liu

Features of dynamic target under the complex natural background change drastically, and

methods based on single feature recognition could not adapt to the drastic changes, while the method based on multi-feature fusion recognition is one of the important research directions. However, the target distance, scale and background environment vary widely in the process of dynamic target tracking; the basic reliability of multi-feature classifiers based on fusion reasoning is unpredictable. This paper proposes a multi-feature fusion recognition algorithm for dynamic target based on reliability regression reasoning. To begin with, target multi-dimensional independent features were extracted; what's more, the basic probability distribution of D-S reasoning based on SVM classifiers was designed according to the mixed matrix distance measure and SVM recognition rate of each feature classifier; furthermore, the relationship between the basic probability distribution and target distance, founded by least square fitting and reliability regression model of D-S reasoning, was acquired. Finally, the method based on multi-feature fusion recognition for moving target was fulfilled under the condition of target distance continuous variation at complex environment. Comparative experiments showed that the algorithm has good generalization ability as well as higher efficiency, and the uncertainty of target recognition in the process of dynamic target tracking was reduced to a large extent.

Venue:	Pacific Hall 4B
Session:	**MoCT2:** Mechanics & Mechanisms
Date/Time:	Monday, 20 November 2017, 13:40 – 15:45
Chair:	Wei Lin / Zaojun Fang

13:40 – 13:55
PDF [241]

MoCT2.1: Simulation and Control of Heave Compensation Winch for Ultra-depth Floating Drilling
Tibing Xiao, Jinyong Huang and Youming Ge

A new kind of multifunctional energy-saving heave compensation winch(HCW) for ultra-depth floating drilling, which has both two function of heave compensation and energy-recycle, is presented based on direct drive volume control(DDVC) and hydraulic transformer(HT) ener-gy-recycle technology. The simulation model for HCW is built by using AMESim software, and the structure for the main controller of HCW is designed, which is consist of a main controller, a HT controller and a direct drive pump source(DDPS) controller. The flowrate calculation method and flowrate distribution algorithm of the main controller are studied, and a flow calculator and a flow distributor are designed. The simulation is conducted by using the estab-lished simulation model. The simulation results shows that the HCW has a good compensation performance, and its compensation accuracy meets the design requirements. So it is proved that the design scheme of HCW is feasible, the si-mulation model established is correct, and the designed con-troller based on flowrate control is effective.

13:55 – 14:10
PDF[247]

MoCT2.2: Research on Polishing Parameters Analysis for Wheel Hub
Hongqiang Chen, Chin-Yin Chen, Zaojun Fang, Huaming Li, Junjie Li and Guiqin Li

Parameters controlling is a key task in the process of polishing with automatic mechanical polishing system, since process parameters is critical to improve surface quality and achieve smoothly remove surface material. Based on Preston equation and Hertz contact theory, the material removal model about the polishing point on the free surfaces has been deduced and verified by combining experiment and simulation. This paper studies the relationship between the material removal depth and process parameters, such as the normal pressure, circular velocity of the tool and the feeding speed, using regression analysis method. The orthogonal experiment is carried out with robot system which based on the surface roughness model of surface parts and using the hub surface as the experimental workpiece. The models provide a key technical basis for removing the material of hub surface evenly and smoothly with robot.

14:10 – 14:40
PDF[257]

MoCT2.3: Analysis on Oil Film Force of Hydrostatic Bearing for Multi-Degree-of-Freedom PM Motor
Zheng Li, Qiushuo Chen, Ruodong Zhi, Lingwei Zhang and Qing Chen

The model and operating principle of a multi-degree-of-freedom permanent magnet synchronous motor is presented. Based on the Navier-Stokes equations in the stable operation, the properties of the velocity variation of the oil film are obtained. The pressure derived from oil film within the motor is analyzed. The pressure distribution of the oil film under different eccentricity and coordinate plane are introduced. These results indicate that the pressure of the oil film in different conditions shows different characteristics. The analysis results are consistent with the actual situation, which provides theoretical and data support for further optimization and experimental design of the motor's structure.

14:40 – 14:55
PDF[121]

MoCT2.4: Development of rotary shear equipment for preparing short metal fibers
Dezhi Yang, Xuefeng Zhou, Taobo Cheng, Kezheng Sun and Dan Huang

In order to obtain high strength short metal fibers efficiently, a new method for preparing short metal fibers by rotating shear metal rope into short length is put forward. Firstly, the principle of rotary shearing is expounded, and the design parameters of the equipment are calculated. Then, rotary shear equipment for preparing short metal fibers has been designed and manufactured. Finally, the short stainless steel fibers with good properties are prepared efficiently by shearing the stainless steel rope with this rotary shear equipment. The results show that it is feasible to produce high quality and high strength metal fiber with new rotary shear method.

14:55 – 15:10
PDF[133]

Research on Modeling and Machining Algorithm of Multi-shear and Multi-punch CNC Transverse Shear Line
Jianhua Tao, Dacheng Li, Tingjun Wu and Yongyan Lu

In view of the disadvantage on the CNC transverse shear line of silicon steel sheet, the paper propose and study a method about multi-shear and multi-punch CNC transverse shear line. Its aim is to achieve the goal of multi-shear and multi-punching, flexibility system, labor intensity and so on. The definition of multi-shear and multi-punch is given by analyzing the mechanical structure and process flow of transverse shear line. And analyzing the existing relationships by establishing TPN model. Finally, this paper creates an optimized mathematical model and proposes the general flow of system algorithm, with emphasis on algorithm design for calculation and optimization.

15:10 – 15:30
PDF[177]

MoCT2.5: Dynamic transient analysis of friction noise in the trimmer blade system
Bo Zhang, Xiliang Chen, Dishan Huan and Zhili Lin

The objective of this paper is to analyze the friction noise of trimmer blade during simulations and experiments. First, a finite element model of the whole blade assembly is established to obtain material properties by using experimental modal analysis. Second, rigid dynamic analysis of the trimmer transmission system gives displacement results which are used as the boundary condition of transient dynamic analysis. Finally, a correlation between experimental and numerical results is proposed successfully for an industrial trimmer blade system. A finding that the trimmer blade friction-induced noise can be predicted by transient dynamic analysis is expected to apply to other applications.

15:30 – 15:45
PDF[199]

MoCT2.6: Modeling of compliance and hysteresis with erasure property in harmonic drive by active loading
Xian Zhang, Gedong Jiang, Chuang Zou and Shuang Wang

In order to understand compliance and hysteresis in harmonic drive better, an improved model considering the erasure property and a corresponding measurement method are proposed. Firstly, the polynomial fit and hereditary integral were applied to model the nonlinear stiffness and hysteresis behavior in harmonic drive. Then the friction effect of Maxwell-slip hysteresis unit was introduced to explain the energy storage and dissipation procedures of the hereditary hysteresis model. As the critical point of system energy discharge is the local torsional angle extremum, the hereditary hysteresis model was improved by replacing the global torsional angle extremum with the local extremum. Afterwards the active loading method by a torsion bar with double motors was used to measure the hysteresis loop and the reliability of the test was verified by repeated tests and statistical analysis. Through this test data, the model parameters were identified by the least square method, and the precision of this compliance and hysteresis model was verified through experiments. Furthermore the erasure property of hysteresis in harmonic drive was

captured by the improved hereditary model and this improvement was verified by a unilateral attenuating loading test. The presented work could serve as a theoretical reference to design a high precision control of harmonic drive in the electromechanical system.

Venue:	Pacific Hall 5
Session:	**MoCT3:** Soft Robotics and Industrial Robotics II
Date/Time:	Monday, 20 November 2017, 13:40 – 15:45
Chair:	Jouni Mattila / Motoji Yamamoto

13:40 – 13:55
PDF[186]

MoCT3.1: Parameter Identification of Flexible Robotic Joint Based on Multi-sensor Information
Zhenwei Huang, Chi Zhang, Chongchong Wang, Guilin Yang and Chin-Yin Chen

In order to achieve high weight to torque ratio, harmonic drive was introduced to robotic joint. However, the nonlinear terms caused by harmonic drive as well as friction makes it more difficult to identify the joint model. The aim of this study is to analyze the dual-mass model of a robotic joint, propose a set of method to identify basic parameters and nonlinear terms including friction and harmonic drive based on multi-sensor information. Neural network method and Stribeck properties are adopted to identify our joint model.Basic parameters such as torque constant and inertial value was mentioned as well. At last, experiment was given to verify the correctness of our method.

13:55 – 14:10
PDF[288]

MoCT3.2: Common Workspace Analysis for a Dual-Arm Robot Based on Reachability
Qinghua Liu, Chin-Yin Chen, Chongchong Wang and Wen Wang

The analysis of the complete 6-D common workspace SE(3) (the special Euclidean group) including the position workspace and the orientation workspace SO(3) (the special Orthogonal group) is important for the dual-arm robot to complete the coordinated task. In this paper, the reachability of the dual-arm robot consisting of two single redundant robot is employed to represent the capability of the common workspace. In order to analyze the reachability, the finite partition of SE(3) including partition of and equivolumetric partition of SO(3) is utilized to discretize the 6-D workspace. Furthermore, an inverse kinematic method based on the joint parameterization and self-optimizing scheme for the redundant robot is proposed, which can find a closed-form solution within joint limits for an arbitrary TCP in the global workspace and a redundancy parameter don't need to be determined in advance. Finally, the reachability analysis method is not only applied to the single redundant robot, but also employed for dual-arm robot in order to obtain the better common workspace.

14:10 – 14:40
PDF[261]

MoCT3.3: Modeling of a 6-DOF parallel manipulator driven by pneumatic muscles
Deyuan Meng, Wei Wei, Chaoquan Tang, Weiping Wang and Xingwang Ding

Since pneumatic muscle has many district advantages compared with electric motor and hydraulic actuator, a 6-DOF parallel manipulator actuated by pneumatic muscles is proposed in this paper. Furthermore, a detailed system model that includes the kinematics and dynamics of parallel manipulator, the pressure dynamics and output force equation of pneumatic muscle, and an equation for the mass flow through the control valve's orifice is developed. The effectiveness of the proposed model is verified by the comparison between simulation and experimental results. Thus, the proposed model can be used in our future work to develop high performance controller.

14:40 – 14:55
PDF[112]

MoCT3.4: Research on a novel robotic arm with non-backlash driving for industrial applications
Longfei Sun and Lijin Fang

Application of industrial robots in the field of manufacturing has increased over the years due to their advantages of large workspace, good flexibility and low cost. However, the stiffness of industrial robots is weak which affects the manufacturing precision seriously as well as transmission backlash. This paper presents a non-backlash robotic arm, the structure of the robot and how to eliminate the transmission backlash of the robot are introduced. Kinematic and dynamic models of the robot are established as well as the directional stiffness analysis based on strain energy and Castigliano's theorem. The results show that the stiffness of the proposed robot is better than that of the industrial robot, and the natural frequency is close to the industrial robot, which proves that the robotic arm can be used for industrial applications as an industrial robot.

14:55 – 15:10
PDF[126]

MoCT3.5: Grasping Model and Experiment of a Soft Robot Gripper with Variable Stiffness
Haibin Yin, Xutao Zhang, Junfeng Li and Jianguo Cao

This research presents a soft robot gripper, which possesses variable stiffness resulting from shape memory alloy (SMA)-1 fiber and actuated by SMA-2 wires. To investigate the grasping capacity of the soft robot gripper, both the theoretical models of the variable stiffness of SMA fiber and grasping force of a soft robot finger are introduced. Based on the theoretical analysis, the grasping force of the soft robot finger doesn't produce before the finger contact with the object under the work of the SMA-2 wires, moreover can be affected from the rigidity of SMA-1 fiber. To verify the analytical results, the soft robot finger with variable stiffness is designed and an experimental setup is built to measure the grasping force. The experimental and simulation results are compared. To check the grasping ability of the soft robot gripper, a two-finger grasping experiment is conducted. The experimental results of the soft robot gripper with variable stiffness indicate that the grasping force of the soft robot gripper has increased with the growth of its stiffness, and the grasping ability of the soft robot gripper grows at least 40%.

15:10 – 15:30
PDF[129]

MoCT3.6: Influence of maximum assistive force of a soft wearable robotic suit on metabolic cost reduction
Shanhai Jin, Shijie Guo, Kazunobu Hashimoto and Motoji Yamamoto

Metabolic cost during walking is positively associated with exercise intensity. As a walking assistive device, one of the major goals should be the maximization of wearers' metabolic benefits. Toward this goal, this paper experimentally evaluates the influence of maximum assistive force (MAF) of an authors' soft robotic suit, which has been developed to assist hip flexion for energy-efficient walking of elderly persons in daily activities, on metabolic cost reduction. Experiment results show that, for a 79-years-old healthy male subject, the metabolic cost reduction rate of the soft robotic suit was not linearly correlated with the value of MAF in the condition of the robotic suit worn and powered on (PON) compared with that of worn but powered off (POFF). Instead, it is interestingly observed that the metabolic cost was significantly reduced by an average of -12% in the PON condition with MAF that the subject felt most comfortable with (24.5N), while the reduction rates were -0.8% and -3.1% in the PON condition with MAFs that the subject felt weak (15.7N) and strong (29.4N), respectively, showing no significant differences between the two conditions. The findings of this study are beneficial for the future development of soft robotic suits that assist hip flexion of elderly persons.

15:30 – 15:45
PDF[162]

MoCT3.7: Joint angle estimation for floating base robots utilizing MEMS IMUs
Xiaolong Zhang, Eelis Peltola and Jouni Mattila

Abstract—This paper describes a novel motion estimation algorithm for floating base manipulators that utilizes low-cost inertial measurement units (IMUs) containing a three-

axis gyroscope and a three-axis accelerometer. Four strap-down microelectromechanical system (MEMS) IMUs are mounted on each link to form a virtual IMU whose body's fixed frame is located at the center of the joint rotation. An extended Kalman filter (EKF) and a complementary filter are used to develop a virtual IMU by fusing together the output of four IMUs. The novelty of the proposed algorithm is that no forward kinematic model that requires data flow from previous joints is needed. The measured results obtained from the planar motion of a hydraulic arm show that the accuracy of the estimation of the joint angle is within ± 1 degree and that the root mean square error is less than 0.5 degree.

Venue:	Pacific Hall 4A
Session:	**MoDT1:** Aerospace Control Systems and Applications II
Date/Time:	Monday, 20 November 2017, 16:00 – 17:30
Chair:	Xiaofei Ma / Lei Liu

16:00 – 16:15
PDF[107]

MoDT1.1: Design and Experiment for A High Precision Reflector
Xiaofei Ma, Qingzheng Song, Qilong Jia and Houfei Fang

Large deployable mesh reflectors for space applications have continuously been developed in the past several decades. A well-designed cable web configuration is essential to the performance of a deployable mesh reflector. Offset feed has gradually been introduced to the mesh reflector design to minimize feed blockage of the RF beam. To increase the stiffness as well as the precision, an elliptical ring truss has been considered for an offset feed reflector that employs a circular axisymmetric parabolic surface. So the scheme of mesh geometry design for large offset deployable reflector needs to be further investigated. This paper presents a new approach to design the cable web for elliptical ring truss reflectors based on the pseudo-geodesic method. This design approach meets the requirements of high precision and uniform distribution of tension forces. First of all, the geometry of an offset reflector is defined by intersecting a parabola with a circular cylinder. The axes of these two geometries are parallel with a given distance which is defined by the offset. The intersection curve is an ellipse. It is important that the cable web can be directly connected to the hard points of the ring truss. The stiffness and precision of the reflector can thus be significantly increased. Also, the circumference of the ellipse is smaller than the circle from traditional approach. Traditional approach used an inclined circular cylinder to intersect the parabola to get a circular ring truss which is much bigger than the elliptical one. Then, a new process has been developed to determine the cable web for the offset feed parabolic surface. The design procedure contains four major steps: (1) selecting a suitable reference sphere and dividing the sphere with pseudo-geodesic; (2) adjusting the pseudo-geodesic based on the facet sizes and ring curvatures; (3) mapping the points from the reference sphere to an ellipsoid; (4) projecting the nodal coordinates from step (3) onto the desired parabolic surface and generating the connections between points. An offset parabolic reflector has been finally used as an example to further discuss and compare different design approaches. Considering static equilibrium of tension members and external mounting forces, an optimization method was introduced to systematically determine an initial profile and tension forces for the reflector. From the results of tension forces given by the optimization method, it can be found that tension forces using the approach developed by this study are more uniform than that using the traditional method. According to design and analysis, a prototype was made to test. By photogrammetry, the surface precision is less than 0.5mm (RMS). The tension level is better than analysis result. The thermal deformation is less than 0.05mm (RMS) for 40℃ temperature change, which is measured by photogrammetry.

16:15 – 16:30
PDF[166]

MoDT1.2: Nonlinear Dynamic Analysis of Deployment of Laminated Planetary Rover Mast
Peibo Hao, Bindi You, Yiming Sun and Dong Liang

In order to study the exact dynamic behavior of flexible laminated appendages undergoing a large rotational deploying motion, the nonlinear dynamic model for laminated planetary rover mast(LPRM) is established taking into account the constitutive relations of laminated composite materials using Hamilton variational principle. Numerical simulations are carried out on the basis of laminated structure and single layer structure of material. The analysis

shows that the structure of laminated composite material has a significant influence on the system dynamics. The results of this paper have important theoretical value and engineering significance for imaging quality of optical equipment and working accuracy of navigation equipment.

16:30 – 16:45

PDF[176]

MoDT1.3: Pointing Behavior of Perimeter Truss Deployable Antenna with a Laminated Reflector

Yiming Sun, Bindi You, Peibo Hao and Dong Liang

Perimeter Truss Deployable Antenna reflector is made of laminated circular plates. The laminated plate would be deformed when it undergoes a large angle rotational motion, and a complex geometric nonlinearity problem would be caused by the coupling effect between the elastic deformation and a large angle rotational motion. According to such reasons, we built a model of laminated plate which is undergoing a large angle rotational motion based on the high-order shear deformation theory. At the same time, we also consider laminated structural parameters and constitutive relations of the plate. And we analyze the coupling relation between elastic deformation and a large angle rotational motion. Moreover, we derive the rigid-flexible coupling dynamics equation using Hamilton variational principle. Furthermore, we verify the necessity of dynamic modeling considering the laminated structure by the numerical simulation.

16:45 – 17:00

PDF[192]

MoDT1.4: Design, Modeling and Shape Control of Bending Moment Actuator

Jian Liang, Min Xiong, Lei Liu and Yanbin Zhao

Shape control of large space structures with high stiffness and large deformation, especially in high control accuracy area, becomes more and more important. In this paper, a bending moment actuator is designed and modeled to implement shape control, which represents large space structures. The structure of the bending moment actuator is designed, which can convert the pushing force of piezoelectric stacks into bending moment. The structure dynamics model of the cantilever beam and hysteresis model of the bending moment actuator are established. The parameter identification is also proposed. Finally, the composite control consisting of PID tuning control and feedforward control is designed to implement shape control. Experimental results show that the maximum displacement of the cantilever beam is 60μm, and the control accuracy is 5μm.

17:00 – 17:15

PDF[291]

MoDT1.5: Fast Steering Mirror and Michelson Interferometer Based Laser Beam Pointing and Steering

Zijun Xiong, Qing Li, Lei Liu and Rui Li

Ultra precision laser pointing and steering are widely used in biomedical, military, aerospace and industrial applications, especially applied to complex environment. The angle accuracy of laser beam may be affected by thermal and vibration environment. This paper develops an electro-optical pointing system using automatic detection and alignment. The laser pointing and steering of the electro-optical system based on fast steering mirror (FSM) are presented. Furthermore, a Michelson interferometer is used to precisely detect the angle error of optical axis. The angle error is then compensated using the FSM.

17:15 – 17:30

PDF[293]

MoDT1.6: Dynamic Analysis of Actuated Joint Considering Multiple Clearances Coupling Flexible Manipulator

Xiang Li, Yang Zhao, Huibo Zhang, Bindi You and Peibo Hao

A dynamic model considering multiple clearances coupling flexible deformation of the actuated joint in space manipulator is deduced in order to improve motion precision and reliability. The nonlinear factors including radial clearance in bearing, backlash in gear pair

and flexible deformation of manipulator are all taken into account in this model. The influence of different rotations, clearances and load values by the system dynamic characteristics is studied by numerical simulation. It is indicated in the analysis results that the coupling relationship between multiple clearances and flexible deformation in the manipulator is a significant effect on the kinematic accuracy and the load distribution in the joint. A series of reasonable values are obtained about clearance, revolution speed and load, which can provide guidance for the design and analysis of the actuated joint.

Venue:	Pacific Hall 4B
Session:	**MoDT2:** Devices – Electromagnetic II
Date/Time:	Monday, 20 November 2017, 16:00 – 17:30
Chair:	Shaoping Bai / Liang Yan

16:00 – 16:15
PDF[220]

MoDT2.1: Magnetic circuit design and performance analysis of a rotary magnetorheological damper with new structure
Junqiang Li, Chenggong Qin, Shijie Guo and Juan Wang

A new structure rotary magnetorheological damper (MRD) was designed. The cross section of the rotor working area is T- shape, as a result, there are several working areas between the rotor and stator, then the working surface is increased, and the rotor moment of inertia is decreased. Base on properties of the magnetorheological fluid (MRF) and magnetic core material, the mechanical and the electric parameters of the damper were calculated. The electromagnetic field analysis was performed with finite element method, then magnetic field quantities of the damper model were got. On this basis, the MRD mechanics properties: yield torque—current was worked out.

16:15 – 16:30
PDF[287]

MoDT2.2: Modeling and analysis of servo valve torque motor based on FEM
Liang Yan, Qiongfang Zhang, Zihao Duan and Zongxia Jiao

The paper investigates the servo valve torque motors in electro-hydraulic servo valves. Through numerical simulation of three-dimensional electromagnetic field, the intrinsic relationship of between the output torque and input current vs. armature angles has been studied in depth. The achieved formula to the actual torque motor has a high reference value for the control of electro-hydraulic servo valve. In the actual use of torque motor, it's dificult to avoid the assembly error. So the influence of assembly error on output torque of the torque motor is analyzed for the first time in details in this paper. The traditional magnetic field simulation is carried out under the default room temperature conditions, while ignoring the influence of ambient temperature for the permanent magnets. This paper also investigates the influence of different ambient temperature on the magnetic characteristic and output torque of the motor.

16:30 – 16:45
PDF[246]

MoDT2.3: Torque Modelling and Current Optimization of Spherical Actuators Built as Electro-magnets Driven Spherical Parallel Manipulators
Xuerong Li, Shaoping Bai, Weihai Chen and Jingmeng Liu

This paper presents a novel design of integrated electro-magnets driven spherical parallel manipulators which produce 3-DOF rotation motion within the workspace. The study in this paper covers inverse kinematics and dynamics, torque modelling and optimization control of current input of spherical parallel manipulators."

16:45 – 17:00
PDF[249]

MoDT2.4: Modeling and Synchronous Control for Target Motion Simulators Driven by Dual Linear Motors
Ran Chen, Zongxia Jiao and Liang Yan

This paper addresses the dynamic modeling and synchronous control for the RF Target Motion Simulators (RF TMS). The investigated TMS is used to simulate the target moving a wide range along x and y directions. The y-axis that moving along x directions is driven by two parallel linear motors which are arranged at both ends of y-axis. A mathematical model about the TMS is built using the Lagrangian equation. From the analysis of the model, it is

the target motion along y directions that causes the two linear motors to be out of sync. To reduce
the synchronization errors of dual linear motors, the effect of target movement on the dual linear motors is seen as disturbance and a sliding mode control(SMC) strategy with two-input-two-output is designed for the dual linear motors. Furthermore, the cross-coupled control (CCC) with PD controller is also studied as a comparison. A simulation process is implemented to verify the effect of proposed control method.

17:00 – 17:15

PDF[194]

MoDT2.5: Design and Control of Eddy Current Damper for Vibration Suppression of Direct Drive Feed System

Sheng Lin, Fei Zhao, Jinhua Chen, Chi Zhang and Junping Wang

The direct feed system is prone to generate vibration due to insufficient damping in the direction of movement. In order to suppress the vibration of direct drive feed system, this paper presents a novel hybrid-excitated eddy current damper functioned as the damping compensation mechanism, which has non-contact mechanical structure and approximate linear damping characteristics. In this work, the characteristics of damper are investigated by Finite Element Analysis (FEA). The motion controller of the system was designed as a cascaded feedback structure with feedforward compensation. The control parameters are adjusted based on the identification of motor dynamic by the unbiased least square (ULS). Finally, the eddy current damper is installed in the motion direction of the direct drive feed system, and the vibration suppression experiments are implemented with 4.5g maximum acceleration. The results show that the root mean square value (RMS) value is reduced by 66% with the proposed method.

17:15 – 17:30

PDF[253]

MoDT2.6: Study on mechanical properties of radial permanent magnet bearing

Dian Zhou and Gang Zhang

The mechanical characteristics of permanent magnetic bearings research is mainly aimed at a certain has the structure parameters of permanent magnet bearings bearing capacity and stiffness. To the design of the permanent magnetic bearing, at first, it needs to undertake structural parameters of magnetic ring of permanent magnetic bearing, so as to maximize the magnetism of permanent magnet ring can play. Therefore, this article mainly aimed at analyzing similar c1 and C1 type combination of the two ring radial permanent magnet bearings, the structure radial permanent magnet bearings and mechanical properties and magnetic ring width, thickness, section area and the relationship between the air gap between the circular, in order to provide some instructions to optimize the selection of the permanent magnet ring.

Venue:	Pacific Hall 5
Session:	**MoDT3:** Identification and Control III
Date/Time:	Monday, 20 November 2017, 16:00 – 17:30
Chair:	Teemu Mononen / Shaohui Foong

16:00 – 16:15

PDF[227]

MoDT3.1: De-coupled Dynamics Control of a Spherical Rolling Robot for Waypoint Navigation

Van Duong Nguyen, Gim Song Soh, Shaohui Foong and Kristin Wood

In this paper, the decoupled control of a nonholo- nomic spherical rolling robot capable of waypoint navigation over planar surfaces is investigated. The robot consists of an external spherical shell driven by an internal two-wheeled differential drive cart fused with odometry and IMU sensors. We derived the robot dynamic model under roll and spin locomotion using Lagrangian, and studied its performance under independent control of these two modes of locomotion. Experiments are conducted to evaluate the control performance on a rectangular waypoint trajectory, captured using an optical motion capture system. The result showed that with our implemented sliding mode controller of the cart's pitch and PD controller of the cart's yaw, the spherical robot can follow the desired set of waypoints effectively.

16:15 – 16:30

PDF[235]

MoDT3.2: Study of control mode and control strategy for direct drive volume control actuating unit of heave compensation winch

Jinyong Huang, Tibing Xiao and Lei Chen

Heave compensation winch (HCW) is a important equipment to ensure production safety of deep-sea floating drilling. Direct drive volume control(DDVC) actuating unit has no throttle losses and overflow losses, so it is very suitable for ultra-high power HCW. The control mode and control strategy for (DDVC) actuating unit for HCW are studied. The experiment bed for(DDVC) actuating unit is built and the bed simulation model is established. By using of PID control strategy, the simulation results show that the double variable control mode of adjusting-speed and adjusting-displacement is better than the single variable control mode. In order to improve further the response speed of DDVC actuating unit, a kind of Bang-Bang+PID dual-mode control strategy is proposed. The experimental results show that the Bang-Bang+PID dual-mode control strategy based on the double variable control model is excellent. These research results offers a useful reference for the design of an actual HCW and other multiple input-output control system.

16:30 – 16:45

PDF[187]

MoDT3.3: The Impact of Initial Alignment on Compensation for Deflection of Vertical in Inertial Navigation

Junbo Tie, Meiping Wu, Juliang Cao, Junxiang Lian and Shaokun Cai

The performance of high precision inertial navigation system depends on not only the quality of inertial sensors, but also the accuracy of the gravity information. The accuracy of inertial navigation system can be improved by deflection of vertical compensation which is suitable for ready-made systems and almost free of cost. In this paper, the impact of initial alignment on compensation of deflection of vertical is investigated, the completed compensation method is proposed and confirmed by airborne and shipborne inertial navigation experiments, and the precision of INS is maximally increased by about 12% after the proposed deflection of vertical compensation.

16:45 – 17:00

MoDT3.4: Study of a 6DOF robot assisted ultrasound scanning system and its simulated

control handle

PDF[208] *Xiaolong Guan, Haotian Wu and Linfei Xiong*

Ultrasound scanning is a commonly used diagnostic method in hospital because of its' high efficiency and limited side effects. In this paper，a robot assisted ultrasound scanning system was developed to help doctors do the remote diagnosis. Doctor could control the ultrasound probe through the Internet from a remote place and receive the ultrasound image in real time. Simultaneously, the robot system does not need to change the doctors' habits for the ultrasound diagnosis and it could be used by doctors quickly.

17:00 – 17:15 **MoDT3.5:** A Novel Stable Control Strategy of Single Cylinder Free-piston Linear Generator

PDF[237] *Feixue Chen, Chi Zhang, Long Li, Peng Sun, Zhe Jiang, Yingzhong Tian and Guanjie Yu*

This paper presents a novel control strategy for a single cylinder free-piston linear generator (FPLG) to stabilize the operation process when combustion fluctuation occurs. The FPLG is composed of an internal combustion engine (ICE), a linear Voice Coil Motor (VCM) and a mechanical spring which is assembled between the ICE and the VCM and functions as a rebounding device. When the piston is in expansion stroke, a two-stage control strategy is employed to guarantee the accuracy of bottom dead center (BDC) position of the piston. In compression stroke, a one-stage reference electromagnetic force is enough to control the TDC on account of the accurate control of BDC. The electromagnetic force of the VCM is controlled by the armature current through following the energy balance equation. The dead point position errors, in-cylinder pressure and piston velocity are fed back to the control loop to regulate electromagnetic force. A simulation model built in MATLAB/Simulink is used to verify the effectiveness of this control strategy. The results validate that this strategy can achieve stable operation with the variation of ±6 mg fuel mass in combustion process. The settling time is less than 0.1s.

17:15 – 17:30 **MoDT3.6:** A Low-Cost Cloud-Extended Sensor Network for Supervisory Control

PDF[214] *Teemu Mononen and Jouni Mattila*

The current automation supervisory control systems are situated in well-restricted areas and require investments in computing hardware and communication systems. In machine automation systems, any additional computing hardware can be cumbersome to install, making upgrades hard to apply. This paper presents a cloud-extended sensor network with supervisory control in a public cloud. The hardware and cloud resources used in the solution are low-cost, reducing the up-front costs compared to the use of high-end components. The system collects data from ST microprocessor (STM)-based sensor nodes that send inertial measurement data using user datagram protocol (UDP). The sensor itself is a Bosch BMI160, a cheap and small inertial measurement unit (IMU). The system is designed to be used in machine automation applications where the frequency of the sensory data produced is hundreds of hertz. The system is to provide low-latency data transfer to the cloud. In the cloud environment, data is collected by a computing service that can be programmed to perform algorithms on it. The system is tested in a setup consisting of five IMU sensors and an angle measurement unit attached to a hydraulically actuated flexible beam. The test setup aims to update a local control system's parameters based on a cloud algorithm and camera measurements of the beam tip position. The control results and communication latency are inspected. The main advantages of the proposed solution are the simple system architecture and cost savings with the use of low-cost sensors and cloud resources. The focus of this study is the functionality of such a system; intricate security issues are beyond the scope of this study.

Day 3: 21 November 2017

AM Sessions

Venue:	Pacific Hall 4A
Session:	**TuAT1:** Devices – Vibrations
Date/Time:	Tuesday, 21 November 2017, 08:30 – 10:00
Chair:	Qingsong Xu / Francis Nickols
08:30 – 08:45 **PDF**[120]	**TuAT1.1:** Study on Creep Hysteresis Characteristics of Piezoelectric Ceramics in the Nano-positioning Stage *Xiankai Cheng, Jun Zhong, Qing Zha and Yong Yu* Piezoelectric ceramics has the advantages of fast response and high resolution of displacement, and is widely used in ultra- precision machining and positioning. In the nano-positioning stage of super-resolution microscopic system, the piezoelectric ceramic drives the flexible hinge to achieve the precise displacement of the sample. In order to realize the precise control of piezoelectric ceramics, it is necessary to grasp the nonlinear characteristics such as creep and hysteresis of piezoelectric ceramics to establish its mathematical model. Through experimental study on the creep characteristic in time domain, it is identified that the piezoelectric ceramics have the basically coincident relative creep rate in the operating voltage range, the mathematical model of the piezoelectric creep is established to weaken the influence of hysteresis. The experimental results show that the corrected hysteresis model has a good matching degree.
08:45 – 09:00 **PDF**[212]	**TuAT1.2:** Design of a Two-Stage Force Amplification Frame for Piezoelectric Energy Harvesting *Shihao Wen and Qingsong Xu* As alternative power sources for replacing batteries, piezoelectric energy harvesters are designed for the applications which demand low-power electronics and sustainable electrical power. This paper presents the design of a new piezoelectric energy harvester with two-stage force amplification frame for the purpose of harvesting energy from human footstep. The two-stage force amplification frame can magnify the walking force applied to the piezoelectric stack and thereby enhances the power output. Analytical model is established to obtain the relationship between the input and output based on elastic beam theory. The frame parameters are designed and optimized to meet the requirements on low-frequency condition and to achieve the maximum force amplification ratio. Finite element analysis is conducted to verify the performance of the proposed frame.
09:00 – 09:15 **PDF**[273]	**TuAT1.3:** An impedance control scheme with lead-lag controller for flexible joint vibration suppression *Chongchong Wang, Guilin Yang, Chin-Yin Chen, Zhenwei Huang, Tianjiang Zheng and Silu Chen* "The current flexible joint impedance control generally has a cascaded structure with both inner torque feedback and outer position feedback loops. The torque feedback loop is designed for the vibration suppression, theoretically, the stronger torque feedback the better vibration suppression performance. But in practical applications, the noise level of the torque sensor limits the vibration suppression performance, together with the system stability. The joint vibration and system stability around the resonant frequency are still

critical problems that need to be considered in flexible joint impedance control. To address this problem, this paper proposes a novel impedance control scheme which introduces a lead-lag network in the inner torque feedback loop as a feed-forward controller. By proper torque feedback controller and lead-lag network design, the proposed control scheme can scale down the amplitude of closed-loop system response as well as improve the phase stabilization around the resonance frequency. Finally, simulation results for the frequency response and the effectiveness of the proposed controller is verified by simulation."

09:15 – 09:30
PDF[255]

TuAT1.4: Analysis and Experimental Study of Hollow Ring Ultrasonic Motor
Zheng Li and Peng Guo

In order to obtain a low-speed output for micro drive applications, a hollow ring ultrasonic motor is proposed and designed. The operation principle and structure of the motor are introduced. The structure of stator is analyzed with modal analysis, harmonic response analysis and transient response analysis by using the finite element analysis software. The resonant frequency and the relation curve of frequency and displacement and the relation curve of time with displacement about the working mode are obtained. The prototype of ultrasonic motor is fabricated according to its design scheme. The torque of the motor is tested through the experimental platform. The above work provides theoretical guidance for the further study of traveling wave ultrasonic motors.

09:30 – 09:45
PDF[223]

TuAT1.5: Design and Development of a Novel Piezoelectric Wind Energy Harvester
Shihao Wen, Haochen Feng, Haopeng Zhou and Qingsong Xu

Energy harvesting refers to the process of acquiring the surrounding energy and converting it into electrical energy. In this paper, a novel wind energy harvester is designed and developed based on the mechanical mechanism design with piezoelectric materials attached onto cantilever beam. It is designed to harvest wind energy from magnets interaction-induced vibration. The influences of different cantilever beams on the magnetic field performances have been analyzed by finite element analysis simulation. Different flabellum and piezoceramic materials have been compared and selected. Pivot design parameters have been determined. A prototype has been fabricated and the influences of different cantilever beams on the harvester's output have been examined. By making use of piezoelectric materials and harvesting circuits, the performance of the developed harvester device has been tested by conducting experimental testing. Future work on the harvester performance improvement has been discussed.

09:45 – 10:00
PDF[226]

TuAT1.6: Feathered Tail and Pygostyle for the Flying Control of a Bio-Mimicking Eagle Bird Robot
Francis Nickols, and Yueh Jaw Lin

Abstract—This paper describes the design principles behind the construction of a 4 degree-of-freedom robot bird tail wing that mimics the pygostyle of a 2.4 metre wingspan eagle bird. The tail provides for elevator-pitch and rudder-yaw control as well as a significant degree of lift that supplements the lift from the main wing.

Venue:	Pacific Hall 4B
Session:	**TuAT2:** Machine Learning
Date/Time:	Tuesday, 21 November 2017, 08:30 – 10:00
Chair:	Aymen Mudheher Badr / Wei Lin

08:30 – 08:45
PDF[135]

TuAT2.1: Object Detection and Recognition of Intelligent Service Robot Based on Deep Learning
Yanan Zhang, Hongyu Wang and Fang Xu

Object detection and recognition is the premise and foundation for intelligent service robot to understand the surrounding environment and make intelligent decisions. In this paper, aiming at the accuracy and real-time performance of object detection and recognition of service robot in complex scenes, an end to end object detection and recognition algorithm based on deep learning is proposed. Firstly, the local multi branch deep convolution neural network is adopted to enhance the feature representation capability of the model by enhancing the convolution module function. Then, combining the anchor point mechanism, the object class and position regression prediction is carried out on the multi-layer feature map. When the local features and the global features are fully fused, the natural multi-scale detection and recognition is realized on multiple receptive fields. Finally, a network acceleration module is designed for GPU parallel acceleration on high performance NVIDIA TX1 embedded board. The experiment was carried out on SIASUN second generation intelligent service robot. The experimental results show that the algorithm has both good accuracy and real-time performance.

08:45 – 09:00
PDF[157]

TuAT2.2: Modeling CGFs Behavior by an Extended Option Based Learning Behavior Trees
Qi Zhang, Quan-Jun Yin and Yue Hu

In military simulation for training, behavior modeling of computer generated forces (CGFs) can be problematic because of the constrained and adaptive model requirements. As an emerging AI scripting technique, behavior trees (BTs) have fantastic advantages of modularity and scalability over finite state machines (FSMs) to encode such CGFs, but still suffers from time-consuming, repetitive endeavor and lack of nuanced variations. In this paper, we propose an extended option based learning method to allow a flexible improvement for a pre-defined BT for CGFs. Based on the original option based learning behavior tree framework, we extend the original BT and propose bottom-up reward accumulation rules to optimize the selector nodes. We apply our method in a predator-prey adversarial simulation scenario to improve a rough BT controller, and experimental results show that our method outperforms its competitors to facilitate BT design by achieving better final behavior performance.

09:00 – 09:15
PDF[258]

TuAT2.3: Novel to improved (MIMO-STBC) system Based on Artificial Neural Network
Aymen Mudheher Badr, Muhammad Aamir and Yi Fei Pu

Multiple-Input-Multiple-Output (MIMO) is a promising application of multiple antennas at both the transmitter and receiver to improve communication performance, achieving spatial diversity. Space Time Block Code (STBC) is a powerful technique used at the transmitter of a MIMO system to obtain high data rates, a larger capacity, and a low Bit Error Rate (BER). In this work, the estimated Multiple-Input-Multiple-Output (MIMO) channel is achieved by using pilot's bits technique and Artificial Neural Network (ANN). Maximum Likelihood (ML) detection was carried out with more than one type of back propagation training algorithm, which were used to make the (BER) of the proposed system closer to the

(BER) of the known channel (MIMO) system.

09:15 – 09:30
PDF[211]

TuAT2.4: A Neurally Inspired Pattern Recognition Approach with Latency-Phase Encoding and Precise-Spike-Driven Rule in Spiking Neural Network
TuAT2.5: *Na Guo, Shaobing Gao, Huajin Tang and Rong Xiao*

Recent years, several advances have been made in spiking neuron networks (SNNs). In this paper, we introduce a novel approach that uses both the latency-phase encoding and the precise-spike-driven (PSD) learning rule for pattern recognition. The empirical results show that our proposed approach can perform quite competitive compared to other usually used encoding and learning strategies in SNNs, when evaluating on the gray OCR dataset and the Address-Event Representation (AER) motion dataset for image classification.

09:30 – 09:45
PDF[106]

TuAT2.6: An SOM-Based Algorithm with Locking Mechonism for Task Assignment
Fei Zhang, Wei Sun, Min Xue, Wenhui Hu and Long Li

In this paper, an improved self-organizing map (SOM) approach is proposed to solve task assignment problem of multiple robots. The purpose is to control a team of robots to accomplish all tasks with a minimal consumption. Compared with conventional self-organizing map approach, there is important improvement in the proposed algorithm. A locking mechanism is proposed to avoid the output neuron oscillation phenomenon which leads to a too many number of iteration. To demonstrate the effectiveness of the proposed algorithm, three groups of experiments are conducted. The experimental results show that the improved algorithm decreases the total energy consumption of entire robot team efficiently, and have less number of iterations than conventional self-organizing map.

09:45 – 10:00
PDF[161]

TuAT2.7: Load Dispatch Optimization of AGC System Based on Improved Genetic Algorithm
Zhiwei Wen

The characteristics of coal consumption of thermal power plants are typical nonlinear and time-varying. It's difficult to obtain an accurate model by traditional method. A multi-objective optimization method based on improved genetic algorithm for load Dispatch of generator units has been proposed. The influence factors of load critical point and response rate has been studied. The genetic programming algorithm is used to automatically fit the coal consumption characteristic curve of the generator units. By adjusting the weights of factors, dynamic dispatch model based on rapidity and economy has been constructed. Simulation result shows the effectiveness in meeting the dispatch requirements and reducing the coal consumption.

Venue:	Pacific Hall 5
Session:	**TuAT3:** Vision and Inertial Sensing
Date/Time:	Tuesday, 21 November 2017, 08:30 – 10:00
Chair:	Jianhua Wu / Shaohui Foong

08:30 – 08:45

PDF[001]

TuAT3.1: Sparse Autoencoder Based Feature Learning for Unmanned Aerial Vehicle Landforms Image Classification

Fang Liu, Lixia Lu and Guangwei Huang

A new algorithm of unmanned aerial vehicle landforms image classification based on sparse autoencoder(SAE) is proposed in view of the drawbacks of single layer sparse autoencoder for feature learning that it is easy to lose the deep abstract feature and the feature lacks the robustness. In this paper, first, by constructing the deep sparse autoencoder, the image layer by layer learning and automatically extract each layer features. Then, in order to improve the feature representations, the each layer feature weights and the reorganized feature set are obtained according to the feature set weighting method. Finally, combining the strong global search ability of genetic algorithm (GA) and the excellent performance of support vector machine(SVM), the image classification is completed efficiently and accurately. The experimental results show that the proposed algorithm can automatically learn the deep feature of the image, and the reorganized feature has high discriminations image representations, which effectively improves the image classification accuracy

08:45 – 09:00

PDF[123]

TuAT3.2: Inertial Sensor-Based State Estimation of Long-Reach Flexible-Link Manipulators

Petri Mäkinen and Jouni Mattila

In this paper, we study the performance of a finite-element-based observer in estimating the flexural degrees of freedom (DOF) of a single-link flexible long-reach manipulator. The observability of the system confirms that all the flexural states of the system can be estimated using a single angular velocity measurement. The inputs to the observer are obtained from retrofittable and low-cost inertial sensors suitable for mobile machines. Results of the observer's performance with different measured states and varying loads are provided. Validation of the end-point position is carried out using an OptiTrack camera system. The performance of the estimated variables as feedback signals in high-performance control is demonstrated using a nonlinear model-based controller based on the virtual decomposition control framework. The test setup consists of a hydraulically driven 4.5-meter-long beam having a maximum tip mass of 70 kg, resulting in a static deflection of -56.7 cm. The initial experiments on the 1-DOF system indicate that the proposed method is effective.

09:00 – 09:15

PDF[174]

TuAT3.3: Research on Recognition Method of Learning Concentration Based on Face Feature

Yaguang Kong and Wenqian Li

With the rapid development of information and Internet technology, online education has become an increasingly popular way of education. Online education allows learners to learn any content at any place and at any time. However, in the process of online learning, the learners' learning mood state is usually not paid attention to. Due to a long time to face monotonous non-communication computer screen, Internet learners are prone to physical or psychological fatigue, resulting in decreased learning efficiency. In view of this phenomenon, taking into account the characteristics of online learning, we define three learning-related expressions: focus, fatigue and normal. We make use of haar-based

adaboost algorithm based on the face detection method to detect the network learners face area, According to the established facial expression model, the facial features of the network learners are extracted, including the eye and mouth features, and then the fuzzy control theory is used to fuzzify the obtained feature data. Finally, the method of comprehensive decision is used to judge the network learning the state of study. The experimental results show that the method used in this paper can be used to classify learners' learning status correctly.

09:15 – 09:30
PDF[251]

TuAT3.4: A Framework of Multi-channel Touch Sensing with Multiple Trackpoints
Yong Han, Jianhua Wu and Zhenhua Xiong

Although multi-axis force sensors have been investigated for several decades, but a low cost, reliable and scalable solution has not yet been provided for multi-channel touch sensing applications. This paper is dedicated to designing
a framework of multi-channel touch sensing via integrating multiple IBM trackpoints, which can be used in six DOF joystick designs, gripper designs and so on. The framework is capable of accommodating up to eight trackpoints with a maximum of sixteen degrees of freedom. Experimental tests has verified that
our solution is feasible and reliable. Besides, the cost of the whole framework is very low, not to mention the supreme scalability. It is found that the cycle time of this framework is less than one hundred milliseconds by using the serial communication. Consequently, it has much practical value in occasions where
the outer sample frequency is less than 10 Hz. This framework can be integrated in specific applications with the design of the trackpoint locations and the algorithm for the trackpoint outputs.

09:30 – 09:45
PDF[202]

TuAT3.5: A Cascade Framework for Masked Face Detection
Wei Bu, Jiangjian Xiao, Chuanhong Zhou, Minmin Yang and Chengbin Peng

Abstract—Accurately and efficiently detecting masked faces is increasingly meaningful, since it can be applied on tracking and identifying criminals or terrorists. As a unique face detection task, masked face detection is much more difficult because of extreme occlusions which leads to the loss of face details. Besides, there is almost no existing large-scale accurately labeled masked face dataset, which increase the difficulty of masked face detection. The CNN-based deep learning algorithms has made great breakthroughs in many computer vision areas including face detection. In this paper, we propose a new CNN-based cascade framework, which consists of three carefully designed convolutional neural networks to detect masked faces. Besides, because of the shortage of masked face training samples, we propose a new dataset called ”MASKED FACE dataset” to finetune our CNN models. We evaluate our proposed masked face detection algorithm on the MASKED FACE testing set, and it achieves satisfactory performance.

09:45 – 10:00
PDF[289]

TuAT3.6: Improving accuracy of feature matching in visual SLAM using spatial consistency of point features
Huijuan Zhang, Chunyan Shao, Zaojun Fang and Si-Lu Chen

Many RGB-D SLAM systems employ the Iterative Closest Point (ICP) with RANSAC as standard algorithm to align point features. However, when the noise in data increases or the offsets between frames are large, the results of RANSAC could be unreliable. In order to improve accuracy of trajectory estimation in such scenes, a novel approach is proposed for feature matching using spatial consistency of point features in RGB-D SLAM. By taking advantage of spatial structure information of point features, our approach can extract correspondences between frames more reliably than feature matching approaches with

RANSAC. Hence, the accuracy of feature matching increases. Results on open dataset show that this approach can improve accuracy and robustness of visual SLAM."

Venue:	Pacific Hall 4A
Session:	**TuBT1:** Parallel Mechanisms & Actuation/Environment
Date/Time:	Tuesday, 21 November 2017, 10:35 – 12:05
Chair:	Guilin Yang / Weiwei Shang

10:35 – 10:50

TuBT1.1: Design and Analysis of an Under-constrained Reconfigurable Cable-Driven Parallel Robot

Nan Zhang, Weiwei Shang and Shuang Cong

PDF[004]

In this paper, we first design a new reconfigurable cable-driven parallel robot, whose cable drawing points can be relocated by extra cables. Compared to most existing cable-driven robots whose cable drawing points are assumed to be fixed, the designed robot can operate in a very large workspace eliminating the possible collision between cables and surrounding environment. Then some interesting and challenging tasks for the robot are outlined, indicating that the designed mechanism may find some potential applications in practice. After that, the kinematics, dynamics, and workspace of the mechanism are analyzed, and dynamically feasible trajectories are designed analytically taking advantage of the unilateral cable tension constraints. Finally, a numerical simulation is carried out to show the effectiveness of the dynamic trajectory planning technique.

10:50 – 11:05

TuBT1.2: Computer-Aided Analysis for Topological Structure of Parallel Mechanisms

PDF[137]

Xiaorong Zhu, Tingli Yang, Sen Yang, Jun Huang and Huiping Shen

The POC theory of topological structure design and analysis for PMs is established by Chinese scholars. The 12 topological characteristics proposed are innate topological invariants of the mechanism which reflect the essential features of structural theory, kinematics and dynamics. But the process of computation and analysis is complicated. In this paper, the principle, algorithm and implementation of computer-aided topological structure analysis of PMs are studied. Firstly, a symbolic description system for PMs is presented to describe the order of the kinematic joints and their orientation relations in a chain, and a kind of matrix expression is promoted to describe the POC set of chain. Then, according to the spatial dependence of the POC set element, the rules of union operation and intersection operation are developed, and the automatic calculation and analysis of POC set, the degree of freedom (DOF) are realized. Consequently, the optimal decomposition algorithm of PMs is studied based on the mechanism composition principle of the ordered single-open-chain (SOC) unit, and the coupling degree is obtained automatically. Finally, the automatic analysis software is developed by VC++, and a case study is presented for a 3T1R PM. The results show that the proposed union and intersection rules are effective and the method of structural decomposition is correct. The algorithm and software proposed are helpful to easily calculate and analysis the topological structure of PMs for more mechanism researchers and engineers.

11:05 – 11:20

TuBT1.3: Efficiency Based Integrated Design of the V3 Parallel Manipulator for Pick-and-Place Applications

PDF[144]

Bin Liao, Lisheng Kuang, Yunjiang Lou and Jiangang Li

Efficiency is critical requirement for high-speed pick-and-place operations. In order to achieve high acceleration, low moving mass/inertia is inevitable, which leads to increasing flexible effects due to the applied thin and light links, and then the accuracy can be difficult to guarantee. In this paper, a general framework of the integrated structure/control design, which is regarded as a preferable technique for flexible manipulators, is presented for pick-

and-place operations. The dynamic model for the V3 parallel manipulator is derived by the finite element method. The proportional-derivative control strategy is applied in the closed-loop system. The structural and control parameters are optimized simultaneously by solving the efficiency based integrated design problem with accuracy constraints. Simulation shows that the integrated design method presents improved system performance on efficiency, and the accuracy is also guaranteed.

11:20 – 11:35
PDF[262]

TuBT1.4: New Cable-Driven Continuun Robot with Only One Actuator
Zhongning Jiang, Yuanxin Luo and Yan Jin

This paper presents a new cable-driven continuum robot by using the time-based control method with only actuator. The continuum robot consists of 3 sections, and each section has 2 DOFs. It is driven by a constant speed motor connected to a series of electromagnetic clutches. The clutches will be activated for providing the motion of the cables. A new time-based control method named 'Time Width Modulation' is proposed to control the continuum robot. Kinematics and workspace analyses are carried out. A prototype is built up and experimental results demonstrate the effectiveness of the proposed design and control method.

11:35 – 11:50
PDF[252]

TuBT1.5: Fatigue life prediction of high-speed railway bearing based on contact stress
Sen Cai and Gang Zhang

In view of the long life and high reliability of high- speed railway bearing, a fatigue life calculation method based on contact stress is proposed by adopting fatigue theory design. Firstly, the load distribution of high-speed railway bearing under radial force and axial force is obtained. Then, the maximum contact stress is obtained by using Hertz contact theory, and the fatigue life value of the bearing is obtained by combining the contact fatigue life curve. By calculating the fatigue life values under different radial loads, different running speeds of train, and compared with the theoretical method of fatigue life of classics, proved that the method is effective, to make up for the defect of the theory of classical methods of fatigue life.

11:50 – 12:05
PDF[240]

TuBT1.6: Research on Risk Fuzzy Comprehensive Evaluation for Construction Engineering Projects based on AHM
Gaoyang Li, Packianather Michael, Chunbao He and Mingguang Liu

It is necessary for investors and construction enterprises to evaluate project risk objectively in order to manage and control project risk effectively and further reduce economic losses. This paper firstly builds projects risk evaluation index system including social risks, economic risks, technical risks, manage risks and equipment risks based on the characteristics of the project risk assessment so that projects risk qualitative evaluation is transformed into a quantitative evaluation problem; Secondly, using each advantages of the Analytic Hierarchical Model (AHM) and Fuzzy Comprehensive Evaluation, the index weights are decided by AHM and then the model of the project risk fuzzy comprehensive evaluation is built; Lastly, a case analysis on the data obtained from experts indicates that it is feasible for the combination of AHM and fuzzy comprehensive evaluation to assess project risk and use this technique more widely.

Venue:	Pacific Hall 4B
Session:	**TuBT2:** Biomechanics II
Date/Time:	Tuesday, 21 November 2017, 10:35 – 11:50
Chair:	Shanhai Jin / Silu Chen

10:35 – 10:50
PDF[290]

TuBT2.1: Structure Modelling of the Human Body Using FGMM
Huifeng Lin, Chenguang Yang, Silu Chen, Ning Wang, Zhaojie Ju and Min Wang

Human motion analysis and posture recognition are receiving increasing attention in the area of computer vision due to their broad range of applications, for example, human-machine interaction. Structure modelling and analysis of human body is important for human motion analysis and posture recognition. In this paper, we propose a novel method based on fuzzy Gaussian mixture models (FGMM) to handle the task of structure modelling. To be more specific, Microsoft Kinect Sensor firstly captures raw 3D data of human body followed by some data preprocessing methods, such as separating the human body from the background and projection from 3D to 2D. Then FGMM is applied to approximate the distribution of the processed 2D points. We conduct some experiments which show that this method has achieved satisfactory performance for body structure modelling.

10:50 – 11:05
PDF[233]

TuBT2.2: Structural Design of Costomized Femoral Prosthesis
Monan Wang, Changqing Li, Mingxu Wang and Juntong Jing

One of the main reasons for the loosening of the prosthesis is that the standard prosthesis cannot meet the individual requirements of the human body, ignoring the shape of the marrow cavity, and cannot match the human marrow cavity effectively. In order to solve the problem of prosthesis loosening, this paper presents the structural design of costomized femoral prosthesis. First, the internal and external contours of the femur were extracted, and then the center line multiple sections method was used to model the handle of the femur. Then, three kinds of ball head structure models are established which are spherical, ellipsoidal and limacon spherical models. Finally, a virtual assembly of the ball head model, the prosthetic stem model and the femur was performed.

11:05 – 11:20
PDF[210]

TuBT2.3: The Finite Element Analysis of the Shape of the Femoral Head Prosthesis on the Influence of the Hip Joint
Monan Wang and Mingxu Wang

Artificial femoral prosthesis replacement is a kind of technology to replace the damaged femoral head caused by femoral head necrosis, femoral neck fracture and femoral tumor in order to relieve patients' femoral head deformities, pain, and dysfunction. In this paper, by establishing the finite element analysis model of the femoral prosthesis, respectively for different shapes of ball head and acetabulum contacts finite element simulation, get the results of the stress and strain, finally, the ball head shape optimization is given.

11:20 – 11:35
PDF[213]

TuBT2.4: The Analysis of Human Walking Stability Using ZMP in Sagittal Plane
Shizhen Meng, Shanhai Jin, Junqiang Li, Hashimoto Kazunobu, Shijie Guo and Shijie Dai

This paper investigates the difference of walking stability between the young and the elderly by using the method of zero moment point(ZMP) in sagittal plane. 3 young and 3 elderly were participated in human walking experiment. Motion capture system was used to collect the experimental data of them. Experimental results show that there are some effective walking stability parameters for comparing the young and elderly. Specifically, they are the

	horizontal distance between ZMP and the center of mass (δZMP), the horizontal distance between ZMP and the ankle, the relationship between δZMP and gait speed, and the trajectories of ZMP in ground plane. These criticism parameters can be used to analyze dynamic walking stability for guiding the development of walking assistance devices.
11:35 – 11:50 **PDF**[218]	**TuBT2.5:** A speed-independent feedback index for walking pattern recognition for a walking assistive robotic suit *Ru Ma, Junqiang Li, Shanhai Jin, Shijie Guo, Hashimoto Kazunobu and Shijie Dai* This paper presents a speed-independent feedback index for walking pattern recognition in real-time control of a robotic suit for elderly persons for energy-efficient walking in daily activities. The presented index maintains almost constant at different walking speed. Additionally, its value becomes minimum in the case healthy walking pattern. The effectiveness of the presented index was experiementally confirmed. Moreover, the experimental results suggest that, as a walking assisitive device for elderly person, it should bring the index as small as possible for improving walking pattern.

Venue:	Pacific Hall 5
Session:	**TuBT3:** Aerospace Control Systems and Applications III
Date/Time:	Tuesday, 21 November 2017, 10:35 – 11:50
Chair:	Qing Li / Jian Liang

10:35 – 10:50
PDF[200]

TuBT3.1: Study on Orbit Control Error Propagation Characteristics by Covariance technique
Wei Li, Xijing Wang, Yanshan Bian and Ying Zhang

The actual orbit will deviate from the nominal orbit when spacecraft maneuvers because of all kinds of error factors. The covariance propagation equations need to be developed for the main error factors when spacecraft maneuvers. Desired effect has been obtained for orbital error propagation by covariance technique. But the dynamic model is over simplified. Therefore the inherent characteristics of the nonlinear system are neglected. In this paper, the orbital error propagation equations are proposed by real linearized method and quasi linearized method, and the perturbation effect of the equations is taken into consideration. Through numerical simulations. The error of orbit prediction is obtained by reference to Monte Carlo method. The results of the proposed orbital error propagation equations are compared with that of real linearized method and quasi linearized method. Results show: the quasi linear model has higher accuracy than the linear model. Orbital control error propagation equations are also proposed by quasi linearized method. The simulation analysis show: the size deviation of the control force has the greatest influence on the error propagation accuracy of orbital control.

10:50 – 11:05
PDF[191]

TuBT3.2: Composite Axis Control System Development of Airborne Electro-Optical Platform
Qing Li, Lei Liu and Shuo Tang

In this paper, the composite axis control system is developed to solve the pointing jitter problem of the electro-optical platform in complex airborne vibration environment. The proposed composite axis control system consists of the gimbaled mirror and piezoelectric fast steering mirror. Robust H_∞ control is employed to enhance the control performance. The pointing and scanning accuracy of the system are verified by experiments. The experiment results show that the pointing jitter of the optical axis is attenuated by 93% and the scanning error is less than 3.7% of the scanning amplitude.

11:05 – 11:20
PDF[286]

TuBT3.3: The Study of Spin Control of Flexible Electric Sail Using the Absolute Nodal Coordinate Formulation
Ran Wang, Yunli Wu, Cheng Wei and Yang Zhao

The electric sail(E-sail) is an advanced propellant-less propulsion system that uses the virtual sail produced by a group of long centrifugally spanned and electrically charged tethers to extract the solar wind momentum to spacecraft thrust. In this paper, the absolute nodal coordinate formulation (ANCF) is applied to obtain a dynamic model of the tether using cable element based on the constitutive model of flexible tether considering the axial and bending deformation. The research applied the voltage modulation of the tether to obtain the attitude control torque for the sail. This study presented a method which used equivalent coning angle and phase angle to control the attitude of the sail concerning the deformation of the tether. The results shows E-sail which is consist of long flexible tethers could be well controlled by using the equivalent parameters.

11:20 – 11:35

TuBT3.4: A Multi-aircraft Conflict Resolution Method Based on Cooperative Game

PDF[284] *Xu Rui Jiang, Ming Gong Wu, Xiang Xi Wen, Congliang Tu and Zi Bo Lin Wang*

Aiming at the problem of multi-aircraft conflict, a real-time conflict resolution method based on Cooperative Game was proposed. Firstly, a Cooperative Game conflict resolution model was constructed, and the maximum coalition welfare solution is introduced to balance the interests of all participants; Secondly, the evaluating indicators of conflict resolution effectiveness were established, Simultaneously, the Utility Function and the coalition welfare function were put forward; Finally, the particle swarm optimization (PSO) algorithm is adopted to minimize the calculation time in the solution. From the simulations of three and six aircrafts conflict we can kwon this method can find the equilibrium point that maximize the coalition welfare function value and obtain the optimal strategy of multi-aircraft conflict resolution.

11:35 – 11:50 **TuBT3.5:** On-orbit identification of spacecraft time-varying moment of inertia using an improved recursive subspace method

PDF[146] *Zhiyu Ni, Jinguo Liu, Xinhui Shen and Chenguang Chang*

A large amount of data are required for the recursive predictor-based subspace identification (RPBSID) algorithm when system state vector is estimated. In this paper, an improved RPBSID method is presented and applied to identify the spacecraft time-varying moment of inertia parameters. Comparing with the original RPBSID algorithm, the improved method does not need to construct the corresponding Hankel matrix for each time instant when solving the state vector. The recursive least squares is used to implement the recursive estimation of the state vector, thereby reducing the computation cost of the identification process. Then, the moment of inertia matrix parameters can be determined recursively from the system state-space model by matrix transformation. In numerical simulations, for a spacecraft with flexible appendages, three cases that may cause the moments of inertia to change with time are investigated. The simulation results illustrate that the proposed recursive method can identify the time-varying moment of inertia parameters effectively and has higher computational efficiency than that of classical RPBSID algorithm.

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