IEEE ROBIO

Sanya, China December 27-31, 2021

PROGRAM

The 2021 IEEE International Conference on

Robotics and Biomimetics

The 2021 IEEE International Conference

on Robotics and Biomimetics

IEEE-ROBIO 2021

Conference Digest

Sanya, China

December 27-31, 2021

IEEE-ROBIO 2021 PROCEEDINGS

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The Institute of Electrical and Electronics Engineers, Inc.

Welcome Message

Welcome to IEEE-ROBIO 2021, a.k.a. the 2021 IEEE International Conference on Robotics and Biomimetics. IEEE-ROBIO 2021 will be held December 27-31, 2021, at the Four Points by Sheraton Hainan, Sanya, China. Known for its original historical villages and contemporary luxury resort hotels, the City of Sanya has been among the most popular tourist destinations in China and worldwide. Its warm weather in winter months has attracted visitors worldwide. IEEE-ROBIO, an established and vibrant international conference, has been held annually since 2004 and has gained increasing international prominence in the field of Robotics and Biomimetics. Due to the COVID-19 Pandemic, IEEE-ROBIO 2020 and 2021 will be combined, and held jointly as a hybrid conference.

The theme of IEEE-ROBIO 2021, "Robotics and Biomimetics Meeting Society's Grand Challenges", reflects fast-growing interests and research effort in development and applications to fill the unmet needs, and their potential impact on people's wellbeing and society. We are pleased to bring you the 2021 conference as a platform where a wide range of scientific topics is exchanged among researchers from different countries.

IEEE-ROBIO 2021 received a total of 398 paper submissions from 12 countries and regions. Upon a careful review process, 332 or 83% of the papers submitted were accepted into the technical program. Of the submitted papers, the top five topics are robot control, bio-inspired robotics, soft-material robots, manipulation, and robot learning. Countries and regions with the most paper submissions (in descending order) are China, Japan, Germany, Hong Kong, Great Britain, and the United States. The five-day conference program of IEEE ROBIO 2021 includes 3 plenary talks and 5 keynote speeches by leading researchers in robotics and biomimetics. The accepted papers of IEEE-ROBIO 2021 are organized into 46 oral sessions and three poster sessions.

IEEE-ROBIO 2021 is a result of a collective effort of many organizations and individuals. Without their support, dedication, and contribution, IEEE-ROBIO 2021 would not have been possible. First, our heartfelt appreciation goes to our sponsors, IEEE Robotics and Automation Society, Shenzhen Academy of Robotics, Chiba Institute of Technology, Nankai University, Shenyang Institute of Automation, CAS, Texas State University, Northeastern University, and NOKOV Co. Ltd. Secondly, we would like to express our gratitude for the tireless effort and work by the members of the IEEE-ROIBO 2021 Organizing Committee in their respective roles and capacities. Third, we would like to thank the members of the IEEE-ROBIO 2021 Technical Program Committee for their hard work which is the most critical in ensuring a fair and careful review process, and an inspiring technical program. Last but not least, we owe the success of this conference to all the authors of the papers submitted, and to the presenters who travel to present their works at the conference. IEEE-ROBIO 2021 is certainly your conference to enjoy and celebrate.

On behalf of the Organizing Committee of IEEE-ROBIO 2021, we welcome you to Sanya and to IEEE-ROBIO 2021, and wish you a great conference and an enjoyable and healthy stay in this fantastic city!

Zhidong Wang, General Chair
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The rising STAR *of Texas*

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GENERAL INFORMATION

Conference Date and Venue

Date: December 27-31, 2021
Venue: Four Points by Sheraton Hainan, Sanya
No. 78 Sanya Bay Road, Sanya 572000 China

Registration Desk

December 27 (Monday)	14:00 to 18:00	1/F, Hotel Lobby
December 28 (Tuesday)	08:30 to 17:00	1/F, Hotel Lobby
December 29 (Wednesday)	08:30 to 18:00	1/F, Hotel Lobby
December 30 (Thursday)	08:30 to 17:00	1/F, Hotel Lobby

Conference Events

Welcome Reception	December 27	Eatery, 2F
Lunches	December 28-30	Eatery, 2F
Conference Banquet and Award Presentation	December 29	Phoenix Ballroom, 1/F
Farewell Dinner	December 30	Eatery, 2F

Official Language

The official language of the conference is English.
All presentations, including discussions and paper submissions, shall be made in English.

Conference Attire

Casual attire is generally recommended for the Welcome and Farewell Receptions while a business suit or a white shirt with a neck-tie at all technical sessions and at the Conference Banquet.

Presentation Specifications

In each oral presentation room, one projector will be available. A laptop will be provided at each meeting room. The presenters should prepare Power Point Slides to facilitate their presentations. All **onsite speakers** in oral sessions should copy your ppt to the meeting room laptop and test it at least 15min before the session starts. The slides and the presentations must be in English. Please test the slides before session start to avoid potential format problems caused by different software versions.
All **online speakers** in oral sessions must send their pre-recorded videos to t.sq.mgt@gmail.com by December 20, 2021. Speakers are required to join the live Q&A session via Tencent Conference.

Duration for each category of oral presentation is listed below:

- Plenary Lectures are scheduled for 60 minutes (including Q&A) each.
- Keynote Lectures are schedule for 40 minutes (including Q&A) each.
- Regular Sessions are schedule for 12 minutes with 3 min Q&A each.

Poster Specifications

Poster session represents an effective and valuable means for authors to present their research results. It offers an opportunity of meeting with interested attendees for in-depth scientific and technical discussions, and establishing new collaborations. Therefore, it is important that you display your results clearly to attract people who have an interest in your team's research work.

Your poster should cover the KEY POINTS of your paper, which include but not limited to background, methods, results and conclusion. Make your poster as self-explanatory as possible. This will save your time for discussions and questions with fellow researchers.

POSTER DIMENSIONS

- Your poster SHOULD have the following dimensions:
- **Poster Size: 90cm (W) x 120cm (H).**
- Please note that printing out your submitted full paper in A4 size format is NOT acceptable as a poster.

POSTER CONTENT

- **Title:** The title of your poster should appear at the top with lettering of at least **42 pt** font size). Below the title, place the names of authors and their affiliations.

- **Text:** Text should be readable from five feet away. Use a minimum font size of **17 pt**. Keep the text brief. Try to use text to introduce the study, explain visuals and direct viewers' attention to significant data trends and relationships portrayed in the visuals, state and explain the interpretations that follow from the data. It is also a good idea to put future research plans or questions for discussion with viewers in your text.

- **Figures:** Each figure should have a brief title. Figures should be numbered consecutively according to the order in which they are first mentioned in the text. Try to use color figures rather than only black and white text to make your poster attractive and highlight the important technical content of your paper. Make sure that the text and the visuals are integrated.

Conference Awards

Best Conference Paper Award

Any paper with original research results can be considered for the Best Conference Paper Award, provided that the research results presented have not been presented anywhere else in the world at the time of paper submission.

Best Student Paper Award

Any original research work can be considered for the Best Student Paper Award, provided that the first author is a student and primary developer of the ideas contained in the paper.

Best Paper in Biomimetics Award

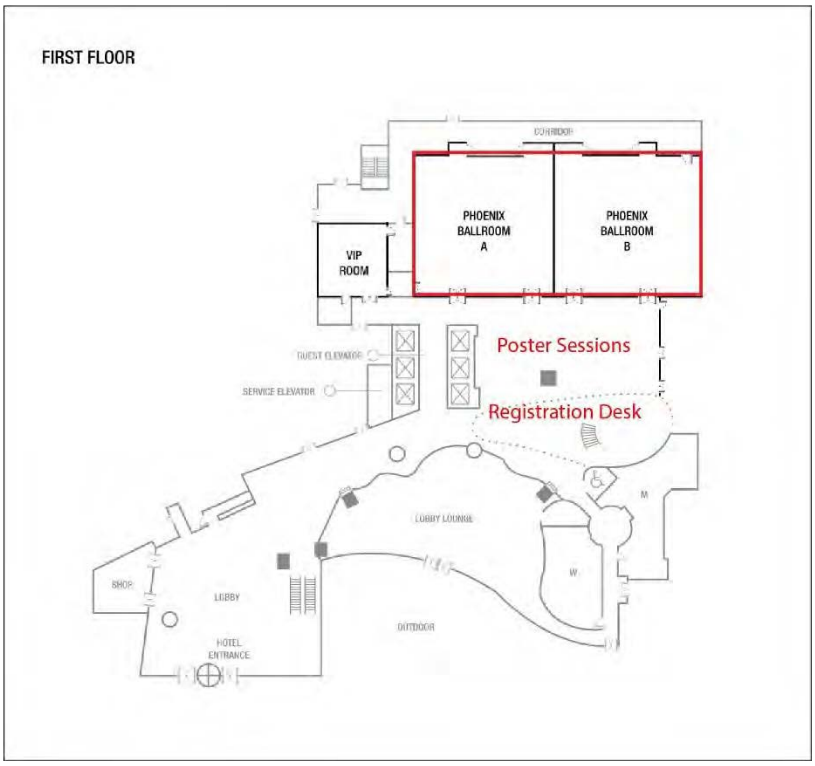
Any paper with original research results in Biomimetics area can be considered for the Best Conference Paper in Biomimetics Award, provided that the research results presented have not been presented anywhere else in the world at the time of paper submission.

T.J. Tran Best Paper in Robotics Award

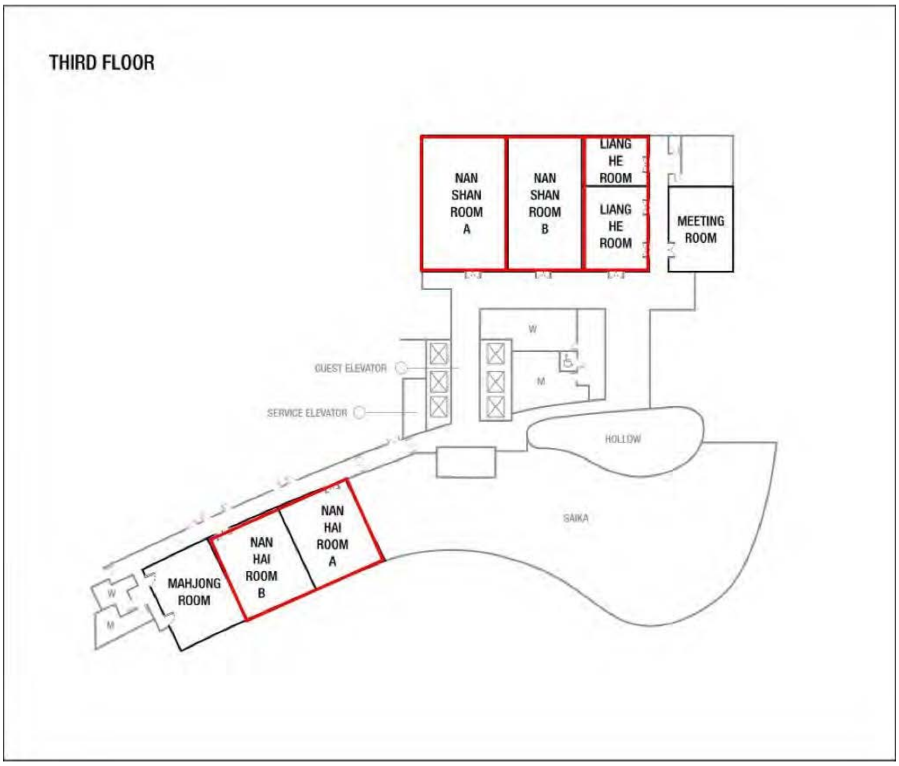
Any paper with original research results in Robotics area can be considered for the Best Conference Paper Award, provided that the research results presented have not been presented anywhere else in the world at the time of abstract submission.

Floor Map

1/F-(Plenary Talks, Keynote Talks, Oral Sessions, Poster Sessions, Coffee Breaks and Conference Banquet)



3/F-(Oral Sessions)



Conference Hotel

Four Points by Sheraton Hainan, Sanya is located at Sanya Bay, just 1 min away from beach. The convenient location will offer easy access to all the local sightseeing and shopping malls, enjoy local food and night life. Sanya Phoenix Airport are just 15 minutes away.

- 5 min from Downtown
- (NO. 8, 15, 25, 26, 30, 34, 57 bus)
- 10 min from Sanya Train Station (NO. 15 bus)
- 15 min from Phoenix Airport (NO. 8, 27, 34 bus)
- 20min from Dadong Sea (NO.8, 25, 15, 34 bus)
- 30min from YalongBay (NO.15, 25, 27 bus)
- 40min from HaitangBay (NO. 34 bus)
- 40min from TianyaHaijiao(NO. 25, 26, 30 bus)

Plenary Talks

Plenary Talk I: Tuesday, December 28, 2021 16:00-17:00

Session Chairs: Hong Zhang, Southern University of Science and Technology;
Fei Chen, The Chinese University of Hong Kong

Dexterous Manipulation of Objects

Aude Billard

Professor
EPFL, Switzerland

Abstract:
Dexterous manipulation of objects is robotics' 21st century primary goal. It envisions robots capable of sorting objects and packaging them, of chopping vegetables and folding clothes, and this, at high speed. Traditional control approaches are insufficient for lack of accurate models of objects and contact dynamics. Robotics leverages, hence, the immense progress in machine learning to encapsulate models of uncertainty and to support further advances on adaptive and robust control.
This talk will provide an overview of efforts in my group to take inspiration in the way humans acquire this exquisite dexterity at manipulating objects. We move away from picking up objects with a gripper and show how all 16 degrees of freedom humanoid hand can be used at last for all their worth, such as to hold several objects in the same hand, or to explore the inside of objects.
I will present new approach using machine learning in conjunction with control to enable robust manipulation in the face of poor models of the robot's dynamics and of the tissues or inertia of the objects manipulated. I will show examples of application of this work to rotate in-the fingers a glasses containing liquid and to cut tissues.

Biography:
Aude Billard is full professor and head of the LASA laboratory at the School of Engineering at the Swiss Institute of Technology Lausanne (EPFL). She was a faculty member at the University of Southern California, prior to joining EPFL in 2003. She holds a B.Sc and M.Sc. in Physics from EPFL (1995) and a Ph.D. in Artificial Intelligence (1998) from the University of Edinburgh. She was the recipient of the Intel Corporation Teaching award, the Swiss National Science Foundation career award in 2002, the Outstanding Young Person in Science and Innovation from the Swiss Chamber of Commerce and the IEEE-RAS Best Reviewer Award. Her research spans the fields of machine learning and robotics with a particular emphasis on learning from sparse data and performing fast and robust retrieval. Her work finds application to robotics, human-robot / human-computer interaction and computational neuroscience. This research received best paper awards from IEEE T-RO, RSS, ICRA, IROS, Humanoids and ROMAN and was featured in premier venues (BBC, IEEE Spectrum, Wired).

Plenary Talk II: Wednesday, December 29, 2021   09:00-10:00

Session Chairs: Jianda Han, Nankai University;

Lianqing Liu, Shenyang Institute of Automation, CAS

MicroHand: A Surgical Robot System for Minimally Invasive Abdominal Surgery

Shuxin Wang

Professor and Vice President

Tianjin University, China

Abstract:

The MicroHand robot system is a minimally invasive abdominal surgery system independently developed by Tianjin University. This presentation describes the design principle of the MicroHand system, and analyzes the kinematic characteristics and dynamic behaviors of the system. The system adopts the design of wire-driven surgical instrument with a decoupled end, which enhances the flexibility of surgeons' operation. A folding RCM manipulator with light-weight structure is designed. The system has performed a large number of animal experiments and multi-center clinical trials. The MicroHand system is the first surgical robot system for minimally invasive abdominal surgery approved by National Medical Product Administration of China. Supported by the 5G technology, the MicroHand system has successfully carried out 50 remote clinical trial operations.

Biography:

Professor Shuxin Wang is the Vice President of Tianjin University (TJU), a Yangtze River Scholar of the Ministry of Education, and the winner of National Science Fund for Distinguished Young Scholars of China. He has been awarded twice the National Science and Technology Award of China. He is the director of the Medical Robotics Joint Research Center co-established by Tianjin University and Wego™ Group, and the director of Ministry of Education Key Laboratory of "Mechanism Theory and Equipment Design". He is a member of the Technical Committee for Multibody Dynamics in International Federation for the Promotion of Mechanism and Machine Science (IFToMM), and the associate editor of IEEE Transactions on Medical Robotics and Bionics. His research interests are surgical robotics, underwater glider, and flexible mechanism systems. He is the author or co-author of over 160 academic papers and has over 80 authorized patents. He and his team are well known for the development of the "MicroHand" robot, which is the first minimally invasive surgical robotic system that has conducted human clinical trials in China. He and his team have also developed a series of Underwater Gliders (named Petrel), which set a world record by diving to 10,619 meters.

Plenary Talk III: Thursday, December 14, 202130, 2021 09:00-10:00

Session Chairs: Lianqing Liu, Shenyang Institute of Automation, CAS;
Ningbo Yu, Nankai University

Dynamic Organization of Global Cell Assembly for Cognition

Chengyu Li

Professor
Institute of Neuroscience
Center for Excellence in Brain Science and Intelligence Technology
CAS, China

Abstract:
My lab is working on neural mechanism underlying cognition, with an aim to advance AI. We are particularly interested in working memory (WM), which maintains information during a delay period by internally generated neuronal activity. We examined the dynamic organization of global cell-assembly activity that encodes WM information via cross-regional sequential spiking. Multiple Neuropixels-probe single-neuron recordings were made from over 60 brain regions in head-fixed mice performing an olfactory WM task. We found that neurons encoded WM during the delay period predominantly by transient activity that formed cross-region sequential waves, with strong constraint set with brain structure. Functional coupling and cross-region loop analysis also revealed strong links between memory-encoding activity waves with brain-wise functional connection. Applying the dynamic rules observed from the mouse brain in designing rate-based and spiking neural networks led to the observation of travelling-wave like spike-train dynamics, better performance in solving of a delayed paired association task, and improved incremental learning in a 10-class handwritten-digit classification task. We are working on recording brain-wise neuronal activity from other cognitive tasks in mice as well as from awake behaving monkeys. Thus, our results uncovered structurally and functionally organized global cell-assembly dynamics mediating WM maintenance and underscored the importance of incorporating principles of neuronal dynamics in designing better AI.

Biography:
LI Chengyu obtained his B.S. degree in Department of Physiology and Biophysics, School of Biological Sciences, Peking University, 1995-1999. Studying between 1999 and 2004, Chengyu Li obtained his PhD degree in Institute of Neuroscience, Chinese Academic of Sciences, Shanghai. Between 2004 and 2009, Chengyu Li studied as Postdoctoral Fellow in Department of Molecular & Cell Biology, Helen Wills Institute of Neuroscience, University of California, Berkeley, CA, USA. His main interests are in the functional circuitry of behavior, including social behavior, working memory, and long-term memory.

Keynote Talks

Keynote Talk I: Tuesday, December 28, 2021 09:00-09:40

Session Chair : Lianqing Liu, Shenyang Institute of Automation, CAS;
Zhidong Wang, Chiba Institute of Technology

Nonlinear Control of Cable-Suspended Flight Transportation Systems

Yongchun Fang

Professor
Nankai University, China

Abstract:
Cable-suspended transportation is an important way of transferring goods and materials by rotorcrafts in complex and hazardous environments, where external disturbances, system uncertainties, as well as the "twofold" underactuated characteristics, bring great challenges to realize safe and smooth deliveries. This talk discusses the latest research results on the dynamics analysis, motion planning, and nonlinear control of the quadrotor transportation systems. Specifically, based on Lagrangian mechanics, a precise model is set up for the "twofold" underactuated aerial transportation system. Then, a time-optimal motion planning technique is proposed to generate a minimum-time trajectory in consideration of state and control constraints. Finally, some nonlinear control algorithms are designed to achieve asymptotic stability, whose performance is verified by various experimental results.

Biography:
Yongchun Fang received the B.S. degree in electrical engineering and the M.S. degree in control theory and application, both from Zhejiang University, P. R. China, in 1996 and 1999, respectively, and the Ph.D. degree of electrical engineering from Clemson University in 2002. From 2002 to 2003, Dr. Fang was a postdoctoral research fellow at the Mechanical and Aerospace Engineering Department, Cornell University. Since 2003, Dr. Fang has been a professor at the Institute of Robotics and Automatic Information System, Nankai University, Tianjin, P. R. China, and he is also a Yangtze River Distinguished Professor of the Chinese Minister of Education. Dr. Fang's research interests include underactuated systems control, visual servoing, AFM-based nano-manipulation, and so on. Dr. Fang is a recipient of the China National Funds for Distinguished Young Scientists, and he won the First Prize of Wu Wenjun Natural Science of Artificial Intelligence in 2017.

Keynote Talk II: Tuesday, December 28, 2021 09:40-10:20

Session Chairs: Ningbo Yu, Nankai University;
Heping Chen, Texas State University

Towards Facilitating Safe and Secure Decommissioning of the Fukushima Daiichi Nuclear Power Station by Remotely Operated Robotics

Kuniaki Kawabata

Professor

Collaborative Laboratories for Advanced Decommissioning Science (CLADS), Japan Atomic Energy Agency (JAEA), Japan

Abstract:

After the accident in 2011, remotely operated robots have been used to decommissioning of the Fukushima Daiichi Nuclear Power Station of the Tokyo Electric Power Company Holdings Inc.. The decommissioning period is estimated for 30 or 40 years and remotely operated robotics is providing essential solutions to ensure safe and secure task execution. In this talk, we e will introduce lessons learned from past remote task executions. In addition, R&D activities of our group on the technologies committing to performance evaluation for the systems and improvement of operator proficiency/spatial awareness in order to maintain safe and secure decommissioning operations will be introduced.

Biography:

Dr. Kawabata received Ph.D from Hosei University and was a Special Postdoctoral Researcher, The Institute of Physical and Chemical Research (RIKEN) in 1997. Then he was Research Scientist then Unit Leader at RIKEN until joining Japan Atomic Energy Agency in 2015 where he became Principal Investigator at the CLADS, JAEA in 2017. He is a senior member of IEEE and a member of JSME, SICE, RSJ and AESJ.

Keynote Talk III: Wednesday, December 29, 2021 10:00-10:40

Session Chairs: Fei Wang, Northeastern University;
Zhidong Wang, Chiba Institute of Technology

Interdisciplinary Robot Research and Its Management

Kanako Harada

Professor
The University of Tokyo, Japan

Abstract:
In the applied research of robots, research collaboration with future robot users is essential. We have been collaborating with surgeons for years to develop autonomous surgical robots; however, the needs of surgeons are often provided in a qualitative manner (for example, “smaller is better”, “the target tissues are very soft”, etc.), and additional needs are given during the evaluation of a prototype, and thus prototyping must be repeated many times. In the research domain of surgical robotics, such repeated prototyping has made it difficult to advance the robotic technologies themselves. In the ImPACT project “Bionic Humanoids Propelling New Industrial Revolution”, we developed elaborate human model equipped with sensors named as Bionic Humanoid, as a means to quantitatively understand the needs of surgeons and to quantitatively evaluate the performance of a prototype. As a concrete example, we developed a new surgical robot named SmartArm in a short period of time using the Bionic Humanoid and also evaluated the SmartArm’s performance quantitatively using the Bionic Humanoid. The project succeeded in demonstrating the importance of project management, and the success led to the launch of a new Moonshot project "Co-evolution of Human and AI-Robots to Expand Science Frontiers" in December 2020. The Moonshot is a national flagship initiative, and this project aims at one of the Moonshot's goals, namely, "By 2050, development of an automated AI robot system that aims to discover impactful scientific principles and solutions, by thinking and acting in the field of natural science”. We will develop AI-robot scientists by interdisciplinary project management. Our project includes not only engineering researchers who will study the next-generation AI and robots, but also scientists who will be the future users of the AI-robots, and mathematical researchers who will make academic contributions to the applied research. In this talk, I will introduce the results of the ImPACT project and the plan of the Moonshot project.

Biography:
Kanako Harada is Associate Professor of the Center for Disease Biology and Integrative Medicine (CDBIM), Graduate School of Medicine, The University of Tokyo, Japan, and she also belongs to the Department of Bioengineering and the Department of Mechanical Engineering, Graduate School of Engineering. She serves as a Project Manager for one of the national flagship projects “Moonshot” by the Cabinet Office. She obtained her M.Sc. in Engineering from The University of Tokyo in 2001, and her Ph.D. in Engineering from Waseda University in 2007. She worked for Hitachi Ltd., Japan Association for the Advancement of Medical Equipment, and Scuola Superiore Sant’Anna, Italy, before joining The University of Tokyo. She also served as a Program Manager for the ImPACT program of the Cabinet Office (2016 - 2019). Her research interests include surgical robotic systems, automation of robots for medical applications, skills assessment, patient models, virtual-reality simulators, and regulatory science.

Keynote Talk IV: Thursday, December 30, 2021 10:00-10:40

Session Chairs: Ningbo Yu, Nankai University;
Heping Chen, Texas State University

Biomimetic on Gecko Locomotion: From Biology Studies to Engineering Applications

Zhendong Dai

Professor

Nanjing University of Aeronautics and Astronautics, China

Abstract:

[Geckos have been studied for many years for their excellent moving abilities on various substrates, including any inclines, even ceilings, and various rough surfaces. Here we report our studies on the gecko adhesive mechanism, attaching and detaching dynamics, locomotion behaviors on anti-adhesive substrate and confined space, bio-inspired adhesive materials and gecko-inspired robot for micro-gravity condition. We have obtained following results: 1) The contact/ tribo-electrifiction is a mechanism more than Van der Waals force for gecko adhesion, we designed an experiment and measured the results showed the evidence of influence of contact / tribo-electrifiction on adhesion. 2) Gecko smartly uses technique of adducting and abducting to make attachment and detachment, this behavior inspired us to design a new pad for gecko-mimicking robot, instand of peeling from substrate. 3) Geckos developed positive and active synergy methods to overcome the difficult to move on anti-adhesive substrate. 4) We have developed bio-inspired adhesive materials and tested they performance for gecko mimicking robot. 5) Then we developed gecko-inspired soft adaptive robot hand and robot for several possible applications.]

Biography:

Dr. Zhendong Dai, Professor, director and founder of the Institute of Bio-inspired Structure and Surface Engineering (IBSS) at Nanjing University of Aeronautics and Astronautics (NUAA), fellow of International Society of Bionic Engineering. His research interesting include tribo-irreversible thermodynamics, biomimetic on gecko locomotion, bio-inspired lightweight structure, brain stimulation of animal moving. He set up research methods and developed facilities to reveal the role of behavior and measure the reaction forces of gecko locomotion, design the micro-structures of adhesive pads and developed the manufacture system, designed gecko mimicking robots for on-orbit applications and confined space inspection. He has published more than 400 papers and patented over 60 inventions. He founded Industry Institute of Bionic Technology, and transferred several technology into products, including 6 dimensional force sensors and force-feed back controlling technology, adhesive materials and soft adaptive robot hands, wall-cleaning robots.

Keynote Talk V: Thursday, December 30, 2021 10:40-11:20

Session Chairs: Fei Wang, Northeastern University;
Fei Chen, The Chinese University of Hong Kong

Trends and Challenges of Unmanned Systems Research

Ben M. Chen

Professor

Department of Mechanical and Automation Engineering
Chinese University of Hong Kong
Hong Kong, China

Abstract:

In this talk, we are to highlight some trends and challenges in the development of autonomous unmanned systems and their integration with AI techniques for real industrial applications. Topics covered are some unconventional unmanned systems hardware platforms, issues on dynamics modeling and control, motion planning, task planning, positioning, localizations, and the integration of unmanned systems with AI techniques for industrial applications.

Biography:

Ben M. Chen is currently a Professor of Mechanical and Automation Engineering at the Chinese University of Hong Kong (CUHK). He was a Provost's Chair Professor in the Department of Electrical and Computer Engineering at the National University of Singapore, before joining CUHK in 2018. He was an Assistant Professor in the Department of Electrical Engineering at the State University of New York at Stony Brook, in 1992–1993. His current research interests are in unmanned systems, robust control and control applications.

Dr. Chen is an IEEE Fellow, CAA Fellow, and Fellow of Academy of Engineering, Singapore. He has authored/co-authored about 500 journal and conference articles, and a dozen research monographs in control theory and applications, unmanned systems and financial market modeling. He had served on the editorial boards of a dozen international journals including Automatica and IEEE Transactions on Automatic Control. He currently serves as an Editor-in-Chief of Unmanned Systems. Dr. Chen has received a number of research awards. His research team has actively participated in international UAV competitions and won many championships in the contests.

IEEE-ROBIO 2021 Conference Program

	December 27 (Monday)
14:00-18:00	Hotel Lobby, 1/F
	Registration
18:00-20:00	**Welcome Reception** at Eatery, 2/F *(for all registered attendees)*

December 28 (Tuesday)

Time						
		Phoenix Ballroom, 1/F				
08:50-09:00	Registration	**Opening Ceremony**				
09:00-09:40		TuKL1 - Keynote Talk I: **Yongchun Fang,** Nankai University, China ***Nonlinear Control of Cable-Suspended Flight Transportation Systems*** (Chairs: Lianqing Liu, Zhidong Wang)				
09:40-10:20		TuKL2 - Keynote Talk II: **Kuniaki Kawabata,** Japan Atomic Energy Agency, Japan ***Towards Facilitating Safe and Secure Decommissioning of the Fukushima Daiichi Nuclear Power Station by Remotely Operated Robotics*** (Chairs: Ningbo Yu, Heping Chen)				
10:20-10:45		*Coffee Break*			TuPo1-**Poster Session I**: (ID: 90, 115, 125, 130, 139, 208, 217, 219, 222, 297, 306, 309, 312, 338, 340, 353, 375, 386, 396)	
		Phoenix Ballroom, 1/F	Nan Shan A, 3/F	Nan Shan B, 3/F	Liang He Room, 3/F	Nan Hai Room, 3/F
10:45-12:00		TuA1-**Manipulation I**: (ID:325, 124, 100, 157)	TuA2-**Micro- & Nano-Robots**: (ID:274, 179, 73, 22, 175)	TuA3-**Bio-inspired Robots**: (ID:182, 341, 261, 88, 129)	TuA4-**Teleoperation**: (ID: 355, 357, 159, 276, 108)	TuA5-**Actuators**: (ID: 394, 65, 156, 366, 333)
12:00-13:00		**Lunch** at Eatery, 2/F *(for all registered attendees)*				
13:00-14:15		TuB1-**Surgical Robots I**: (ID:110,144,379, 278,170)	TuB2-**Sensing & Estimation I**: (ID:236, 248, 263, 266,273)	TuB3-**Mobile Robots I**: (ID:48,146,215,47,3)	TuB4-**Human-Robot Interaction**: (ID:172, 315, 376, 308, 164)	TuB5-**Robot Design & Analysis I**: (ID:30, 76, 87, 132, 127,)
14:15-14:35		*Coffee Break*			TuPo2-**Poster Session II**: (ID: 92, 72, 64, 54, 53, 42, 395, 342, 275, 256,209, 207, 205, 150, 145, 141, 204, 346, 397)	
14:35-15:50		TuC1-**Manipulation II**: (ID:21,334,311, 252,153)	TuC2-**Robot Design & Analysis II**: (ID:220, 101, 198, 77, 13)	TuC3-**Robot Learning**: (ID:105, 194, 221, 249, 193)	TuC4-**System Design & Optimization I**: (ID:180,149,327, 191,360)	TuC5-**UAVs I**: (ID: 269, 289, 372, 35, 199)
		Phoenix Ballroom, 1/F				
16:00-17:00		TuPL1 - Plenary Talk I: **Aude Billard**, EPFL, Switzerland ***Dexterous Manipulation of Objects*** (Chairs: Hong Zhang, Fei Chen)				

December 29 (Wednesday)

Time		Phoenix Ballroom, 1/F				
09:00-10:00	Registration	WePL2 - Plenary Talk II: **Shuxin Wang**, Tianjin University, China ***MicroHand: A Surgical Robot System for Minimally Invasive Abdominal Surgery*** (Chairs: Jianda Han, Lianqing Liu)				
10:00-10:40	Registration	WeKN3 - Keynote Talk III: **Kanako Harada**, University of Tokyo, Japan ***Interdisciplinary Robot Research and Its Management*** (Chairs: Fei Wang, Zhidong Wang)				
10:40-11:00	Registration	*Coffee Break*		WePo3-**Poster Session III**: (ID: 212, 17, 18, 24, 26, 29, 31, 44, 62, 94, 109, 228, 246, 305, 314, 320, 329, 392)		
	Registration	Phoenix Ballroom, 1/F	Nan Shan A, 3/F	Nan Shan B, 3/F	Liang He Room, 3/F	Nan Hai Room, 3/F
11:00-12:30	Registration	WeA1-**Planning & Control I**: (ID: 192, 299, 316, 322, 113, 367)	WeA2-**Underwater Robots**: (ID: 202, 50, 61, 185, 253, 95)	WeA3-**EMG**: (ID: 347, 234, 318, 111, 251, 317)	WeA4-**SLAM**: (ID: 37, 257, 303, 285, 227, 370)	WeA5-**Soft Robots**: (ID: 385, 365, 218, 250, 271, 89)
	Registration	**Lunch** at Eatery, 2/F *(for all registered attendees)*				
13:30-15:00	Registration		WeB2-**Mobilization & Learning**: (ID: 332, 79, 313, 158, 96)	WeB3-**Dynamics & Control I**: (ID: 40, 195, 12, 119, 230, 84)	WeB4-**Legged Robots**: (ID:38, 166, 279, 225, 56)	WeB5-**BCI**: (ID:126, 265, 326, 270, 55)
15:00-15:30	Registration	*Coffee Break*		WePo4-**Poster Session IV**: (ID: 27, 32, 63, 68, 74, 98, 99, 118, 123, 107, 272, 287, 290, 300, 324, 331, 361, 371)		
15:30-17:15	Registration		WeC2-**Rehabilitation & Assistive Robots**: (ID:184, 336, 288, 81, 359)	WeC3-**Robotic Exoskeletons**: (ID:302, 335, 368, 75, 142)	WeC4-**System Design & Optimization II**: (ID:354, 374, 377, 382, 277)	WeC5-**Dynamics & Control II**: (ID:373, 85, 178, 229, 356)
18:00-20:00		Phoenix Ballroom, 1/F				
		Conference Banquet and Award Presentation *(for all registered attendees)*				

December 30 (Thursday)

Time		Phoenix Ballroom, 1/F				
09:00-10:00	Registration	ThPL3 - Plenary Talk III: **Chengyu Li**, Institute of Neuroscience, CAS, China ***Dynamic Organization of Global Cell Assembly for Cognition*** (Chairs: Lianqing Liu, Ningbo Yu)				
10:00-10:40	Registration	ThKN4 - Keynote Talk IV: **Zhendong Dai**, Nanjing Univ. of Aeronautics and Astronautics, China ***Biomimetic on Gecko Locomotion: From Biology Studies to Engineering Applications*** (Chairs: Ningbo Yu, Heping Chen)				
10:40-11:20	Registration	ThKN5 - Keynote Talk V: **Benmei Chen**, The Chinese University of Hong Kong, HKSAR, China ***Trends and Challenges of Unmanned Systems Research*** (Chairs: Fei Wang, Fei Chen)				
11:20-11:40	Registration	*Coffee Break*		ThPo5-**Poster Session V**: (ID: 161, 104, 137, 162, 196, 216, 223, 243, 255, 262, 268, 280, 296, 304, 307, 393, 321, 389)		
	Registration	Phoenix Ballroom, 1/F	Nan Shan A, 3/F	Nan Shan B, 3/F	Liang He Room, 3/F	Nan Hai Room, 3/F
11:40-12:55	Registration	ThA1-**Motion Planning I**: (ID:5, 138, 293, 328, 43)	ThA2-**Sensing & Estimation II**: (ID:345, 301, 384, 186)	ThA3-**Detection & Learning**: (ID: 45, 28, 295, 233, 20)	ThA4-**Robot Vision I**: (ID:235, 240, 254, 188, 155)	ThA5-**Planning & Control II**: (ID:160, 165, 167, 169, 224)
	Registration	**Lunch** at Eatery, 2/F *(for all registered attendees)*				
14:00-15:30	Registration	ThB1-**Motion Planning II**: (ID:36, 106, 152, 163, 291, 183)	ThB2-**UAVs II**: (ID: 4, 15, 116, 213, 214, 174)	ThB3-**Dynamics & Control III**: (ID: 319, 66, 67, 122, 283)	ThB4-**Robot Vision II**: (ID: 10, 11, 33, 41, 128, 102)	ThB5-**Surgical Robots II**: (ID:117, 388, 323, 294, 197, 121)
15:30-15:50	Registration	*Coffee Break*		ThPo6-**Poster Session VI:** (ID: 8, 69, 86, 91, 151, 154, 171, 206, 232, 238, 264, 298, 310, 339, 344, 348, 350, 398)		
15:50-17:05	Registration	ThC1-**Motion Planning III**: (ID: 337, 383, 286, 140, 52)	ThC2-**Mechanism Design**: (ID:147,176, 200, 201, 203)	ThC3-**Mobile Robots II**: (ID: 358, 6, 231, 49, 80)	ThC4-**Image Processing**: (ID: 103, 34, 133, 177, 9)	ThC5-**Planning & Control III**: (ID: 390, 148, 378, 71)
		Farewell Dinner at Eatery, 2F *(for all registered attendees)*				

Technical Sessions

Tuesday, December 28

TuPo1: Poster Session I

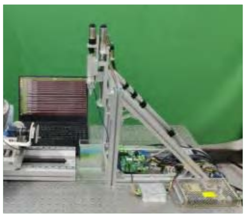
Room : Foyer, 1/F, 10:20-10:45, Tuesday, December 28, 2021

TuPo1(1) 10:20–10:45

Adaptive Step Puncture Strategy Based on Online Identification of Tissue Shore Hardness

Li Changle, Yu Chuanyou, Zhang Leifeng, Ban Guang, Fan Yilun, Yubin Liu,Zhao Jie, Member, IEEE
Harbin Institute of Technology, Harbin, Heilongjiang, China

- Design of puncture end tool
- Puncture strategy proposal process
- Following experiment



Puncture end tool

TuPo1(2) 10:20–10:45

Critical Information Selection for Affective Brain-computer Interfaces Based on Brain Function Networks

Jinying Bi and Xin Yan
College of Information Science and Engineering, Northeastern University, China
Fei Wang and Jingyu Ping
Faculty of Robot Science and Engineering, Northeastern University, China

- Design to find the best threshold for constructing brain function networks.
- Design to obtain the best frequency bands and channels combination for emotion recognition.
- Verify that the critical information for emotion recognition is reasonable.
- Reduce the amount of calculations and simplify the electrode device for emotion recognition.

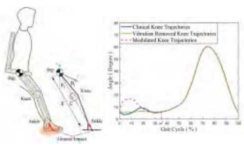
Critical channels

TuPo1(3) 10:20–10:45

Knee Trajectory Modulation for Impact Reducing of Lower Limb Exoskeletons

Long Zhang[1], Guangkui Song[1], Chaobin Zou[1], Hong Cheng[1], Rui Huang[1]and Jing Qiu[2]
[1]School of Automation and Engineering, UESTC, Chengdu, China
[2]School of Mechanical and Electrical Engineering, UESTC, Chengdu, China

- The shock-absorbing model (SAM) based on the humanoid spring-damping system has been proposed for walking assistance exoskeletons.
- Enables reduction of Ground Reaction Force (PGRF) without bulky mechanical structures.
- The proposed approach has been verified by the AIDER exoskeleton.



A shock-absorbing model (SAM) based active knee trajectory adjustment to reduce the Peak of Ground Reaction Force (PGRF) is proposed for lower limb exoskeletons.

TuPo1(4) 10:20–10:45

Grasping Force Control for a Soft Finger with SMA Actuator based on Inverse Models and Lag Compensations

Haibin Yin and Jian Yang and Jiayuan Wang
School of Mechanical and Electronic Engineering, Wuhan University of Technology, China

- The research object is the grip control of soft fingers driven by SMA.
- Control methods include model prediction, lag compensation, PID and PIP-P3.
- The experiment includes step instruction experiment and sine instruction experiment.
- The control performance of predictive controller based on mathematic model is better.

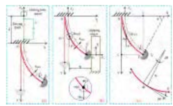


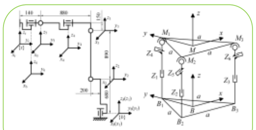
Figure (a) driving force, (b) grasping force and (c) kinematics

TuPo1(5) 10:20–10:45

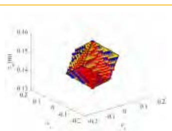
A motion assignment strategy based on macro-micro robotic system for enhancement of kinematic performance

Yaohua Zhou[1,2], Chin-Yin Chen[2,*], Renfeng Zhu[1,2], Ye Tang[2,3], Guilin Yang[2], Weijun Wang[2], Yaonan Li[4]
[1]University of Chinese Academy of Sciences, [2]Ningbo Institute of Materials Technology and Engineering, [3]Zhejiang University of Technology, [4]Shenzhen Academy of Robotics, *Corresponding author

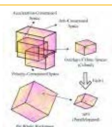
- Kinematics analysis of the macro and the micro;
- Construction of the numerical workspace of the micro as a search set;
- Traversal of the search set and select the optimum while considering the smoothness of the trajectory.



Kinematic Configuration



Numerical Workspace



Trajectory Constraints

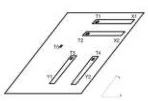
Simulation Results

TuPo1(6) 10:20–10:45

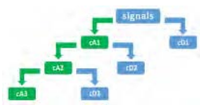
MEMS Accelerometer Stability and Temperature Compensation for Long Term Structure Surveillance System

Yingjiao Rong, Zengshuai Qiu, Guang Luo, Congcong Ma, Guangyi Shi, and Juanhui Zheng*

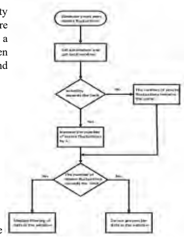
A noise filter for static monitoring environment is designed. The static stability algorithm is designed by studying railway monitoring data. Temperature compensate system is designed, temperature compensation model fitted with a polynomial equation is proposed. Experimental result shows the difference between the heating curve and the cooling curve, a method for judging the heating and cooling according to the readings of the temperature sensor is proposed.



Dual-axis sensor with redundant structure



Signal processing steps by wavelet decompose



Filter logic for short term violent fluctuation

TuPo1: Poster Session I (cont.)

Room : Foyer, 1/F, 10:20-10:45, Tuesday, December 28, 2021

TuPo1_2(7) 10:20–10:45

Compatible Structure Design of a Lower Limb Exoskeleton for Gait Assist

Dong Zhao, Xia Zhang and Hao Fu
College of Mechatronics and Automobile Engineering, Chongqing Jiaotong University, China

- A novel human-exoskeleton compatible configuration scheme obtained through configuration optimization
- Exoskeleton ankle motion area compatibility with the human ankle motion area verified through simulation
- Comparison of the compatibility of human-exoskeleton motion with the compatibility scheme and other 7 types of non-compatibility schemes
- The deviation of the human-exoskeleton joint angular displacement under the compatibility scheme is the smallest

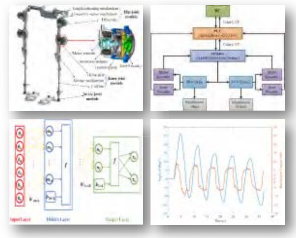
TuPo1_2(8) 10:20–10:45

Dynamic Modeling and Compliant Control for a Lower Extremity Exoskeleton Robot Based on BP Neural Network

Zhitao Ling, Yixin Shao, Di Shi and Wuxiang Zhang
Beihang University

Abstract— In order to realize the active control of the swinging leg of a 2-DOF lower extremity exoskeleton robot with complex multi-link drive, a dynamic modeling and compliant control method based on BP neural network is proposed in this paper. Firstly, the dynamics data of the joints are acquired by static experiments under no-load and the double-joint motion experiments under sine and cosine signals. Then, the dynamic model of the robot is established by building and training a BP neural network. A variable frequency motion experiment under no-load is taken to verify the correctness of the model. Based on the BP neural network and the PID controller, a compliant control method is designed. Finally, no-load static experiment and motion tracking experiment are carried out. Experiments show that the trained model can well estimate the human-robot interaction torque under both static and dynamic conditions, and motion intention recognition and motion tracking are realized by the designed control method. In addition, the weight of the exoskeleton is compensated to reduce the burden of the exoskeleton on people.

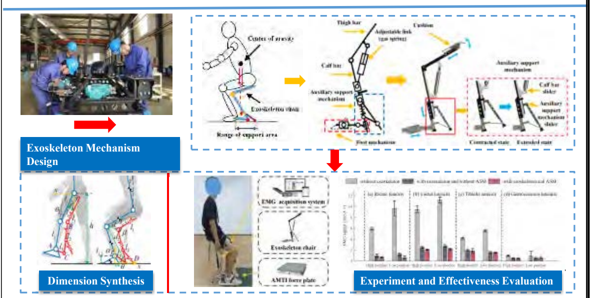
Index Terms— *Lower Extremity Exoskeleton*, *Dynamic Modeling*, *BP Neural Network*, *Compliant Control*.



TuPo1_2(9) 10:20–10:45

Design of a Passive Exoskeleton Chair with an Auxiliary Support Mechanism for Assembly Tasks

Yibo Han, Ying Liu*, and Wuxiang Zhang

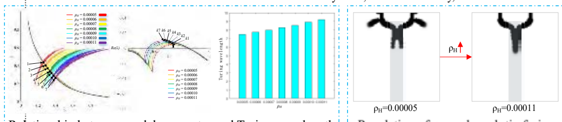


TuPo1_2(10) 10:20–10:45

IEEE ROBIO 2021

A way for regulating branch tip fusion behavior based on Turing mechanism

Shan Guo and Yaowei Liu
Institute of Robotics and Automatic Information Systems, Nankai University, China



Relationship between model parameter and Turing wavelength | Regulation of ρ_H on branch tip fusion

- ◆ A regulation method of branch tip fusion behavior based on the Turing mechanism of branch tip fusion behavior is established.
- ◆ The regulation method is realized by regulating the key model parameters to adjust Turing wavelength.
- ◆ By decreasing the parameter ρ_A (secreting rate of activator by differentiated cells) or increasing ρ_H (secreting rate of inhibitor by differentiated cells), the fusion behavior of branch tips could be promoted.

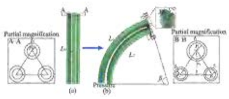
Nankai University

TuPo1_2(11) 10:20–10:45

the Soft Continuum Robot Based on Large Deflection Theorem

Manrong Wang and Wenbiao Wang
College of Mechanical Engineering, Zhejiang University of Technology, China
Guanjun Bao
College of Mechanical Engineering, Zhejiang University of Technology, China

- A new soft continuum robot dynamic model modeling idea.
- The pneumatic soft continuum robot is regarded as a variable-stiffness beam.
- The soft continuous robot pressure model is used to solve the deflection curve equation.

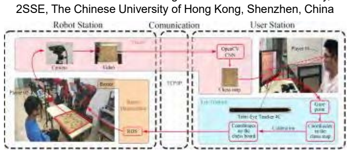


Schematic diagram of soft continuum robot plane bending

TuPo1_2(12) 10:20–10:45

Towards Enhanced Social Well-being for the Disabled Using Humanoid Robot with Eye Tracker

Xueyi Zhang[1,2], Xingchao Wang[1,2], Jiahao Fang[1,2] and Zhenglong Sun[1,2]
1Shenzhen Institute of Artificial Intelligence and Robotics for Society, China
2SSE, The Chinese University of Hong Kong, Shenzhen, China



- An intelligent system that can assist the disabled to play Chinese chess with other normal people without any physical movement by using a robot with a visual sensor.
- The system consists of three parts: visual recognition, eye tracking, and robotic manipulation.
- the system was able to complete the task in 13 out of 15 rounds

TuPo1: Poster Session I (cont.)

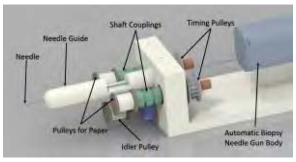
Room : Foyer, 1/F, 10:20-10:45, Tuesday, December 28, 2021

TuPo1_3(13) 10:20–10:45

Multiple Tissue Sample Collection Device for MRI Guided Transrectal Prostate Biopsy: Preliminary Study

Farrukh Anique, Jung Ki Jo, and Seong Young Ko

MTSCD Collects and stores tissue samples, automatically, taken in a real time MRI Guided Prostate Biopsy. It uses two layers of paper to collect and trap the tissue samples. These layers rolls over a pair of pulleys which have been connected and synchronized with timing pulleys. The device can be actuated with a motor, or without a motor using already available backward motion of the biopsy gun.



3D model of proposed MTSCD

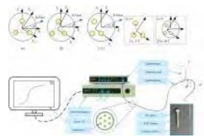

Collected Samples (top) & Needle after Sample Sweeping (Bottom

TuPo1_3(14) 10:20–10:45

An orthogonal calibration method for the multi-core fiber shape sensor

Zhenxing Wang，Meng Liu and Hao Liu
Shenyang Institute of Automation, China
Jie Li, Shenyang Jianzhu University, China
Zhidong Wang, Chiba Institute of Technology, Japan

- The installation error analysis of multi-core fiber shape sensor
- Proposed an orthogonal calibration method and operation specification
- Derive the shape reconstruct algorithm based installation parameters
- Verify the calibration method by digital simulation and sensor experiments


The Installation error analysis and calibration method

TuPo1_3(15) 10:20–10:45

Denoising of Pulse Wave Signal by Wavelet Packet Transform

Yibin Lu, Min Li, Biteng Wu, Youyuan Tang and Zijian Wei
School of Mechatronic Engineering and Automation, Shanghai University, China

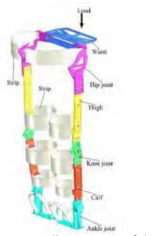
- A high sampling rate two-channel pulse wave signal measuring instrument based on AFE4490 and STM32H743IIT6 is designed
- The noise analysis of two-channel pulse wave signal is carried out by frequency domain and wavelet packet transform
- In this paper, the heart rate accuracy experiment and PPT value comparison experiment under different sampling rates were designed to verify the data accuracy of the dual-channel pulse wave measuring instrument

TuPo1_3(16) 10:20–10:45

Structural Design and Analysis of Unpowered Exoskeleton for Lower Limb

Zhenya He[1,2], Siqi Chen[1], Xianmin Zhang[1], Guojian Huang[3], Junming Wang[1]
[1] Guangdong Provincial Key Laboratory of Precision Equipment and Manufacturing Technology, South China University of Technology, China
[2] The State Key Laboratory of Fluid Power and Mechatronic Systems, Zhejiang University, China
[3] School of Electrical Engineering, Guangdong Mechanical & Electrical, China

- An unpowered exoskeleton for lower limb was designed.
- The load to the user and energy consumption while walking can be reduced simultaneously.
- It has the advantage of light weight, simple structure, and good adjustability.

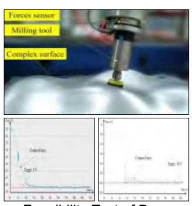

The overall structure of the unpowered exoskeleton

TuPo1_3(17) 10:20–10:45

Feasibility Study of Stable Contact Force Control for Bone Milling

Wenyuan Liang
College of Engineering, Peking University, China
National Research Center for Rehabilitation Technical Aids, China

- The feasibility study is operated based on a 6-DOF medical robot.
- The milling control algorithm is a hybrid position/force control algorithm.
- The experiments of feasibility test include the milling on the flat surface and the complex surface with large curvature.
- The experimental results show that the proposed control algorithm could maintain a stable milling force between the milling tool and the surface along the normal direction.



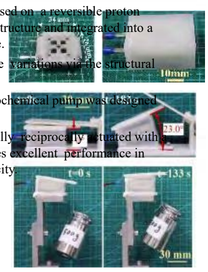
Feasibility Test of Bone Milling with a 6-DOF Robot

TuPo1_3(18) 10:20–10:45

A soft actuator with integrated pneumatic source using electrically induced liquid-to-gas conversion

Yao Xu, University of Chinese Academy of Sciences, Beijing, China
Ting Wang, Shenyang Institute of Automation, Chinese Academy of Sciences, Shenyang, China
Zhidong Wang, Chiba Institute of Technology, Chiba, Japan

- •An electrochemical pump was designed based on a reversible proton exchange membrane fuel cell (RPEMFC) structure and integrated into a soft actuator to work as a pneumatic source.
- •The electrochemical pump is robust to pose variations via the structural design.
- •An soft actuator with an embedded electrochemical pump was designed and could be easily fabricated.
- •The proposed soft actuator can be electrically reciprocally actuated with low-voltage DC power (<3 V), and provides excellent performance in terms of deformation stroke and load capacity.



Room : Foyer, 1/F, 10:20-10:45, Tuesday, December 28, 2021

TuPo1_4(19) 10:20-10:45

Control and Collaboration of Self-Balancing Spherical Robots

Liyan Chen, Sheng Bi, George Zhang, Shujia Qin*, and Ning Xi
Shenzhen Academy of Robotics, China

- Restricted space environment (e.g. narrow tunnels, pipelines, and high obstructions) has detection challenges
- Omnidirectional spherical robot has the preferable characteristics of low power consumption, high stability, and high mobility
- This paper introduced a compact and flexible self-balancing spherical robot system with a motion controller based on a mix of existing design patterns

Prototype of the spherical robot

TuA1: Manipulation I

Session Chairs: Wenfu Xu and Yanding Qin

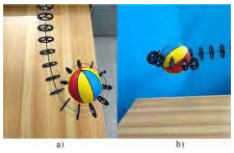
Room : Phoenix Ballroom, 1/F, 10:45-12:00, Tuesday, December 28, 2021

TuA1(1) 10:45-11:00

Variable-Cross-Sectional Continuum Manipulator capable of grasping by whole-arm wrapping

Zuan Li, Yixin Xie, Han yuan*, Wenfu Xu
School of Mechanical Engineering and Automation,
Harbin Institute of Technology Shenzhen, China

- A Variable-Cross-Sectional Continuum Manipulator (VCSCM) was designed
- Realize wrapping and grasping objects through whole-arm operation.
- The kinematics model of continuum manipulator is established based on the assumption of Piecewise Constant Curvature.
- The space trajectory accuracy test and winding grasp experiment were carried out using a prototype.



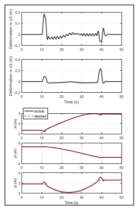
Grasping by whole-arm wrapping

TuA1(2) 11:00-11:15

Adaptive Trajectory Tracking and Vibration Suppression Control for Flexible Space Manipulator

Zeyuan Huang, Gang Chen, and Hong You
School of Automation, Beijing University of Posts and Telecommunications, China

- The dynamic model of non-planar flexible space manipulator is established
- The dynamic model is decomposed according to the time scale of movement response for better astringency
- A two-time scale controller with uncertain model parameters is designed for trajectory tracking and vibration suppression simultaneously

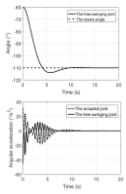

The effect of the proposed two-time scale controller

TuA1(3) 11:15-11:30

Reachable range analysis and position control of the free-swinging joint for an underactuated space manipulator

Yingzhuo Fu, Qingxuan Jia, Gang Chen, and Hanxiao Wang
School of Automation, Beijing University of Posts and Telecommunications, China

- Dynamic coupling model of a space manipulator with a free-swinging joint failure is established.
- The reachable range of the free-swinging joint is analyzed through considering the possible influential factors.
- A position control algorithm considering the controllability for the space manipulator is proposed.


The trajectory of the free-swinging joint and actuated joint

TuA1(4) 11:30-11:45

Distributed Force Synchronization for Networked Robotic Manipulators with Transmission Delays

Zhang Xiaodong[1], Chao Ma[2], Tao Xiao[1] and Liziyi Hao
[1] Beijing Institute of Spacecraft System Engineering, Beijing, China
[2] University of Science and Technology Beijing

TuA2: Micro/Nano Robots

Session Chairs: Haibo Yu and Xiao Liang

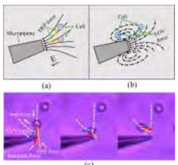
Room : Nan Shan A, 3/F, 10:45-12:00, Tuesday, December 28, 2021

TuA2(1) 10:45–11:00

A Novel Micropipette Robot for Cell Manipulation Based on DEP and EOV

Shengjie Yang and King Wai Chiu Lai
Department of Biomedical Engineering,
City University of Hong Kong, Hong Kong SAR, China

- Low-frequency and low-voltage electric field combine dielectrophoretic effect and electroosmotic vortex
- High directivity net force acts on the target cell
- Accurately guides the manipulation process by monitoring cell deformation



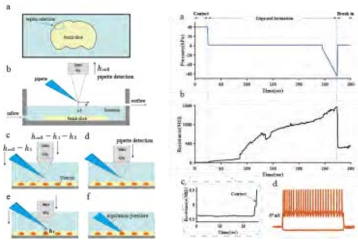
Experimental schematics of DEP and EOV

TuA2(2) 11:00–11:15

Robotic Visual and Electrical Guided Whole-Cell Patch Clamp

Jinyu Qiu, Minghui Li, Huiying Gong, Mingzhu Sun, Xin Zhao and Qili Zhao*
Institute of Robotics and Automatic Information System, Nankai University, China

- A novel robotic visual and electrical-guided whole-cell patch clamp method was developed.
- Electrode pipette detections were realized respectively under the field of different objectives lens for a fast and precise electrode pipette localization. The contact detection, seal formation and break-in are based on electrode resistance.
- The results on neurons in the V1 pyramidal cell layer in mouse brain slices show that this method doubled the operation speed before cell sealing (3 min 35 s Vs 8 min), reduced the whole cell operation time by 44% and without reducing the success rate (60% Vs 60%).

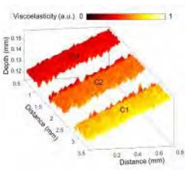


TuA2(3) 11:15–11:30

Simultaneous depth and viscoelasticity measurement of micro-structures using echo effect in a photoacoustic imaging system

Wenxiu Zhao, Haibo Yu, Xiaoduo Wang, Lianqing Liu, and Wen Jung Li
Shenyang Institute of Automation, Chinese Academy of Sciences, China
Yangdong Wen
Urban Rail Transportation, Southwest Jiaotong University, China
Wen Jung Li
Department of Mechanical Engineering, City University of Hong Kong, China

- A photoacoustic method was utilized for viscoelasticity measurement when the depth is kept constant.
- Echo effect was utilized in a photoacoustic imaging system to measure viscoelasticity and depth simultaneously.
- Assisted by echo effect, there is no need to adjust the photoacoustic imaging system.

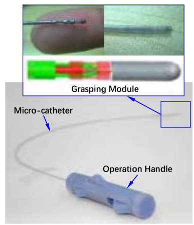


TuA2(4) 11:30–11:45

Design and Modeling of a Reloadable Coil-Delivery Instrument for Aneurysm

Chuanxiang Zhu, Yifan Wang, Yue Ding, Xiang Wang, and Kai Xu
School of Mechanical Engineering, Shanghai Jiao Tong University, China

- Design and manufacture a reloadable coil-delivery instrument to lower the cost of detachable coils.
- The coil is clamped by the claws made from nitinol rods and released by claw retraction.
- Model the large-deflection mechanics of pre-curved nitinol rods using elliptic integral.
- Experimentally verify the instrument's function and the effectiveness of the mechanics model.



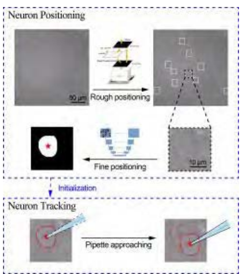
The prototype of the reloadable coil-delivery instrument.

TuA2(5) 11:45–12:00

Positioning and Tracking of Neurons in Label-free Tissue Slice for Automatic Patch Clamping

Huiying Gong, Jinyu Qiu, Lu Li, Yatong Yao
Qili Zhao, Xin Zhao, Mingzhu Sun*
Institute of Robotics and Automatic Information System, Nankai University, China

- A positioning and tracking method of neurons in label-free tissue slice was proposed.
- Neuron selection, positioning, and segmentation were achieved by designing a two-step positioning algorithm based on convolutional neural networks.
- The contour obtained was used to track the target neuron consistently and accurately, since the neuron will shift as the pipette approaching.



TuA3: Bio-inspired Robots

Session Chairs: Jianjun Yu and Wenyuan Chen

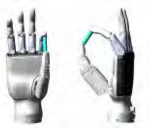
Room : Nan Shan B, 3/F, 10:45-12:00, Tuesday, December 28, 2021

TuA3(1) 10:45–11:00

Kinematics Analysis and Grasping Simulation of a Humanoid Underactuated Dexterous Hand

Xiangyan Zhang and Qinjian Zhang*
Beijing Information Science and Technology University, China
Haiyuan Li* and Bin Zhang
Beijing University of Posts and Telecommunications, China
Yingpeng Cai
Beijing Inspire Robots Technology Company, China

- The forward and inverse kinematics of the underactuated dexterous hand are derived.
- The workspace of a human hand and the dexterous hand are analyzed.
- The correctness of kinematic analysis is verified in simulation.
- Grasping different objects with appropriate actions is simulated.



Simulation of grasping by the underactuated dexterous hand

TuA3(2) 11:00–11:15

Goal-driven Motion Control of Snake Robots with Onboard Cameras via Policy Improvement with Path Integrals

Lixing Liu, Xian Guo and Yongchun Fang
College of Artificial Intelligence, Nankai University, China.

- A periodic visual localization strategy is proposed to realize onboard visual localization.
- A two-stage motion control framework based on the PI2 and gait equation is proposed to realize the motion control of the goal-driven motion.

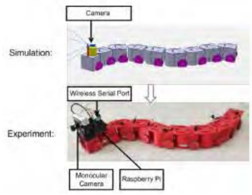


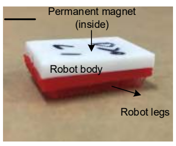
Fig. 1: The snake robot used in the simulation and experiment.

TuA3(3) 11:15–11:30

Bioinspiration to Robot Locomotion implementing 3D printed Foxtail Grass

Qing Lu, Behzadfar Mahtab, Fan Zhao,
Ki-Young Song, and Yue Feng
School of Mechatronical Engineering, Beijing Institute of Technology, China

- 3D printing microfibers for anisotropic structure, mimicking foxtail grasses
- Bioinspired multipede robot
- Magnetic manipulation for locomotion control
- Simulation of stick-slip motion of the anisotropic structure



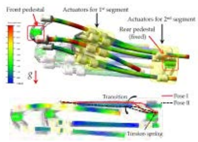
3D printed multipede robot with anisotropic legs

TuA3(4) 11:30–11:45

Bio-inspired continuum robot for out-pipe climbing and confined space navigating

Mingyuan Wang, Liang Du, Jianjun Yuan, Sheng Bao
Shanghai Robotics Institute, Shanghai University, Shanghai, China
Shugen Ma
Department of Robotics, Ritsumeikan University, Shiga, Japan.

- We propose a robotic solution based on continuum robot with compliant mechanisms
- This robot can imitate the locomotion principles of both caterpillars and inch-worms
- Dynamic simulations including task space motion and confined space navigating based on flexible multi-body dynamics method are performed, some phenomena are discussed.



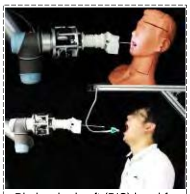
Flexible simulation setting and deformation results of the continuum robot.

TuA3(5) 11:45–12:00

Bio-inspired Soft (BIS) Hand for Tele-operated COVID-19 Oropharyngeal (OP) Swab Sampling

Jianshu Zhou, Wei Chen, Shing Shin Cheng, and Yunhui Liu
Mechanical and Automation Engineering,
The Chinese University of Hong Kong, Hong Kong
Lingbin Xue, and Michael C F. Tong
The Department of Otorhinolaryngology, Head and Neck Surgery,
The Chinese University of Hong Kong. Hong Kong

- In this work, we present a bio-inspired soft (BIS) hand dedicated to safe and dexterous OP swab sampling.
- The BIS hand is designed based on human hand sampling observation, which well replicates the pinch function of human fingers and orientation adjustment of the human wrist.
- A teleoperation-based controller with VF constrain is applied for intuitive teleoperation with safety guarantee.
- The results show our proposed BIS-hand enabled robotic system provides a human manual sampling comparable dexterity and safety.



Bio-inspired soft (BIS) hand for OP swab sampling

TuA4: Teleoperation

Session Chairs: Hongpeng Wang and Bo Zhu

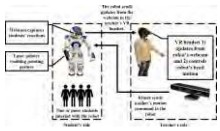
Room : Liang He Room, 3/F, 10:45-12:00, Tuesday, December 28, 2021

TuA4(1) 10:45-11:00

Robot-Enhanced Telepresence of Remote Teachers for Effective Distance Learning

Haozhe An, Michael Bowman, Songpo Li and Xiaoli Zhang
Colorado School of Mines, USA

- Distance learning is limited by the lack of physical interaction.
- Teleoperation empowers remote teachers to effectively communicate information.
- Learning experiences are improved with the teacher using the robotic system

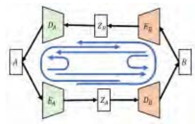


TuA4(2) 11:00-11:15

Robust Motion Mapping Between Human and Humanoids Using CycleAutoencoder

Matthew Stanley, Lingfeng Tao, and Xiaoli Zhang
Colorado School of Mines, USA

- Accurate and robust motion mapping between human and humanoid robots are required for intuitive robot control.
- Current models focus on accuracy (ability to map motion within the training workspace), but models should also be robust (apply mapping rules outside of the training workspace).
- Create CycleAutoencoder to improve robustness using three pairs of loss functions.

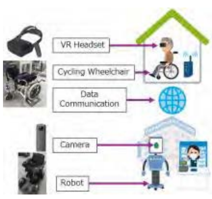


TuA4(3) 11:15-11:30

Evaluation of an Avatar Robot with a Physically Immersive Telepresence

Koen Hertenberg, Jose Salazar, Amir Tafrishi, Ankit Ravankar and Yasuhisa Hirata
Department of robotics, Tohoku University, Japan

- Elderly or disabled people might have difficulty going out and interact with their community
- Common telecommunication and telepresence systems have limited interactivity and do not physically engage the users
- We developed an immersive physically engaging telepresence system useable for elderly or disabled people
- Researched the relationship between physical engagement and transported presence and immersion



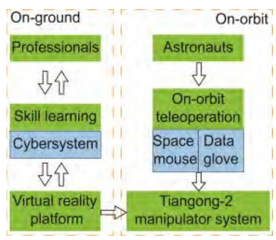
Simple System Overview

TuA4(4) 11:30-11:45

Teleoperation of the Tiangong-2 Space Manipulator System

Chongyang Li, Zainan Jiang, Yang Liu, Ziqi Liu and Hegao Cai
State Key Laboratory of Robotics and System,
Harbin Institute of Technology, Harbin

- Two subsystem: the on-orbit teleoperation subsystem and the on-ground skill learning subsystem
- Designing a on-ground mapping method of the CyberGlove based on the human and dexterous hand model.
- Establishing a grasping database and analyzing the variance between finger joints.
- Designing a on-orbit quick calibration method of the CyberGlove based variance analysis result.

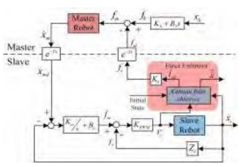


TuA4(5) 11:45-12:00

Force Sensations of Delayed Telerobotic System with Kalman Filter

Hongbing Li and Xun Nie
Department of Instrument Science and Engineering, Shanghai Jiao Tong University, China
Evgent Magid and Dingkun Gui

- An estimation approach based on Kalman filter is proposed to deal with the dynamic interaction between robot with unknown environment.
- A Kalman filter based estimator has been designed to estimate the driving current and speed of the joint actuator.
- The feasibility of using motor current to estimate tool-environment contact forces is explored.



Block diagram of the proposed force sensation controller

TuA5: Actuators

Session Chairs: Ying Zhang and Han Yuan

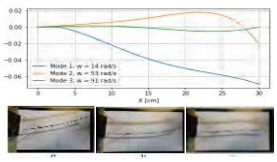
Room : Nan Hai Room, 3/F, 10:45-12:00, Tuesday, December 28, 2021

TuA5(1) 10:45-11:00

Experimental Analysis of the Vibrating modes of a Fish-Like Piezoelectric Actuated Beam

Arthur Barbosa and Maíra Martins
Mechanical Engineering Department, University of Sao Paulo, Brazil

- Impact Tests
- MFC Actuation
- Polynomial Approximation



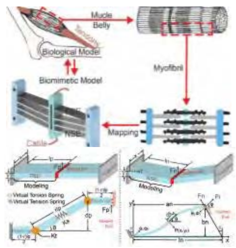
Mode Shapes: (a) first (blue), (b) second (orange) and (c) third (green).

TuA5(2) 11:00-11:15

Design and Modeling of a Novel Biomimetic Variable Stiffness Actuator Inspired by Skeletal Muscle

Yaowei Song, Yisheng Guan*, Chaoqun Xiang, Bin Wang, Zhihao Liang and Jie Wang
Biomimetic and Intelligent Robotics Lab (BIRL), Guangdong University of Technology, Guangzhou, China

- The biomimetic design of the variable stiffness actuator (BVSA) improves the compliance in human-robot interaction.
- The biomimetic representation of tendons and the muscle belly as cables and a composite compliant mechanism, respectively.
- The actuator weight and complexity are reduced, and the linearity of stiffness adjustment is improved.
- The stiffness characteristics of the BVSA are simulated, demonstrating a fine variable stiffness performance similar to that of skeletal muscle.



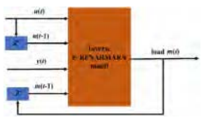
Schematic of the skeletal muscle biomimetic design

TuA5(3) 11:15-11:30

Dynamic Hysteresis modelling and Load Prediction for Pneumatic Artificial Muscles

Ying Zhang, Yuhao Zhao, Meng Liu, Shuopeng Wang, Rixin Wang and Lina Hao*
School of Mechanical Engineering & Automation, Northeastern University, Shenyang 110819, China

- The load-depended dynamic hysteresis of PAMs is tested and analyzed.
- A dynamic asymmetric hysteresis model of PAMs under different loading conditions is proposed.
- A new idea about load perception for the PAM is proposed.



TuA5(4) 11:30-11:45

Modeling, Analysis, and Experimental Results of the Skeleton-Embedded Fiber-Guided Water Hydraulic Actuator

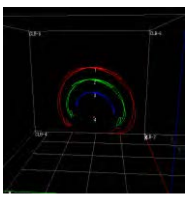
Siqing Chen[1], He Xu[1], Qiandiao Wei[1] and Weiwang Fan[1]
[1] Harbin Engineering University

TuA5(5) 11:45-12:00

Pneumatic Multi-Pocket Elastomer Actuator for Simulating Tendon Driven Human Muscles

Jiang Wu and Motoki Shino
Department of Human and Engineered Environmental Studies, The University of Tokyo, Japan

- Focus on the actuator has the characteristics of softness and portability, which can safely and effectively couple the force of the actuator to the human body, often used in surgical support instruments and wearable devices
- Devise a method to adjust the shape of the actuator during operation by changing the structure of the internal chamber and the external shape of the actuator



The trace of the 4 markers on the actuator in the 3D space

TuB1: Surgical Robots I

Session Chairs: Yanding Qin and Yu Dang

Room : Phoenix Ballroom, 1/F, 13:00-14:15, Tuesday, December 28, 2021

TuB1(1) 13:00–13:15

Pre- and Intra-operative Dynamic Registration for Total Knee Arthroplasty Based on CT Image Annotation

Yanding Qin, Mingqian Ma, Lin Shen, Zhichao Song, and Hongpeng Wang
College of Artificial Intelligence (Tianjin Key Laboratory of Intelligent Robotics), Nankai University, China
Institute of Intelligence Technology and Robotic Systems, Shenzhen Research Institute of Nankai University, China
Hongpeng Wang and Xinwei Chen
Fujian University Engineering Research Center, Minjiang University, China

- A robotic surgery system was proposed for total knee arthroplasty.
- The proposed surgical system includes navigation module and surgical operation module.
- A method based on CT image annotation was proposed to address the dynamic registration.

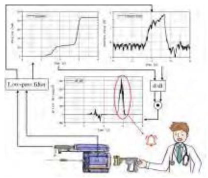
The prototype of the TKA robotic surgery system

TuB1(2) 13:15–13:30

Penetration Identification Criterion and Augmentation for Pediatric Lumbar Puncture

Yiyun Wang and Hongbing Li
Department of Instrument Science and Engineering, Shanghai Jiao Tong University, China
Jing Zhang
Shanghai Children's Medical Center, Shanghai Jiao Tong University School of Medicine, China

- This paper proposes a novel penetration criterion to sensitively capture the defining loss of resistance moment.
- Augmented haptic perception is realized to better inform the needle-tissue interaction while offering decent compliance with friction compensation.
- One-time success rate, insertion accuracy, operation confidence and stability is greatly improved with the compact mechanism and auxiliary system design.



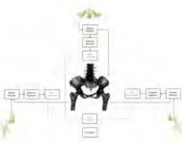
Overall control principle of the robot-assisted lumbar puncture system with proposed penetration identification criterion

TuB1(3) 13:30–13:45

Globally Learnable Point Set Registration Between 3D CT and Multi-view 2D X-ray Images of Hip Phantom

Jin Pan, Zhe Min, Ang Zhang, Han Ma
Rπ Lab, The Chinese University of Hong Kong
Max Q.-H. Meng
Rπ Lab, The Chinese University of Hong Kong

- We explore the Globally learnable 2D-3D Point Set Registration in multi-view settings
- We implement the method in the real-world clinical dataset, hip joint dataset. The images captured from different views can speed up the convergence of searching and improve the accuracy.

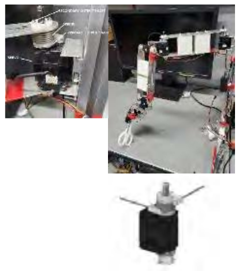


TuB1(4) 13:45–14:00

An anthropomorphic surgical simulator arm based on series elastic actuators with haptic feedback

Sriranjan Rasakatla, Azumi Ueno, Antonio Galiza, Takahiro Ario, Ikuo Mizuuchi and Bipin Indurkhya
Tokyo University of Agriculture and Technology

***Abstract*— We present the Epsilon-1 surgical simulator, which was designed using series elastic actuators (SEA) with off the shelf components. This low-cost alternative provides surgical training to surgeons by providing haptic feedback from an environment simulated by physics engines. We describe the hardware and software architecture of the surgical trainer arm in this paper. This is the first Anthropomorphic surgical arm because its dimensions and motions are of anthropomorphic nature. We present here our intuitive software simulation environment that gives multiple views for the comfort of the surgeon trainee.**

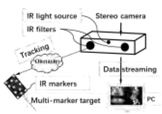


TuB1(5) 14:00–14:15

Towards Tracking by 2D-target Registration for Surgical Optical Tracking System

Tinghua Zhang, Zhengyan Zhang, Botao Lin, Junnan Xue, Jiaole Wang and Shuang Song
School of Mechanical Engineering and Automation, Harbin Institute of Technology (Shenzhen), China

- Question: The occlusion problem in OTS
- Solution: A tracking by 2D-target registration approach
- Contributions:
- (1) Tracking the multi-marker 2D-target in a 3D point cloud registration manner;
- (2) Occluded simulations and experiments were carried out.



Conceptual view of the proposed system

TuB2: Sensing & Estimation I

Session Chairs: Houde Dai and Hongpeng Wang

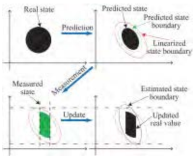
Room : Nan Shan A, 3/F, 13:00-14:15, Tuesday, December 28, 2021

TuB2(1) 13:00–13:15

A Practical SVD-based Ellipsoid Estimation for Active Modeling of Robotic Ureteroscope

Xiangyu Wang, Qingyi Zeng, Yanding Qin and Yongchun Fang
College of Artificial Intelligence, Nankai University, China

- The sequence processing technology is utilized to apply ESMF to real-time active modeling of the robotic ureteroscope
- The singular value decomposition is engaged on the envelope matrix of ellipsoid estimation to avoid possible numerical instability
- The feasibility and robustness of the modified ellipsoid estimation are validated in active modeling of the robotic ureteroscope



The ellipsoid estimation in 2-D surface

TuB2(2) 13:15–13:30

Mobile Sensor Array Tracking Approach for Electromagnetic Driven Capsule Robot

Yue Wan, Yujie Liu, Xiaoyang Wu, Shuang Song* and Jiaole Wang
School of Mechanical Engineering and Automation, Harbin Institute of Technology (Shenzhen), Shenzhen

- This paper proposed a mobile sensor array tracking approach for the capsule robot
- The array is linked with the movable platform to ensure a widen-scale localization
- The proposed method was to remove the partial magnetic field from the EM coil

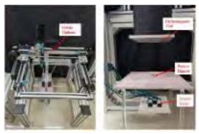


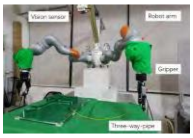
Figure caption is optional, use Arial 18pt

TuB2(3) 13:30–13:45

Cable Assembly in Constrained Environment Based on Contact State Transition Graph

Ruiqiang Wang, Dayuan Chen[1], xin Jiang[1*] and yunhui Liu[2]
[1]Harbin Institute of Technology (Shen Zhen), China
[2]The Chinese University of Hong Kong, China

- Use the vision system to track the cable shape in constrained environments.
- The manipulation sequence is planned taking consideration of the contact state transition graph which describes the contact state transition of the cable given specified action.
- The proposed method is verified by experiments in which a cable is inserted through a three-way pipe.

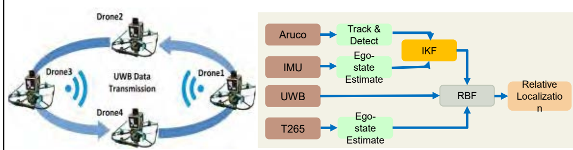


A robotic manipulation system for the cable

TuB2(4) 13:45–14:00

Relative State Estimation with Observer-based Intermittent Kalman Filter and Radial Basis Function Neural Network

Yujun Huang, Peihan Zhang and Wei Dong
Shanghai Jiao Tong University



□ **Multi sensor**: Camera, IMU, UWB and T265;

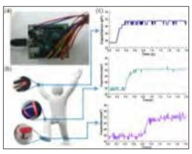
□ **Fusion scheme**: IKF(Intermittent Kalman Filtering) and RBF(one Neural Network);

TuB2(5) 14:00–14:15

A Low-Cost Conductive-Textile Based Multifunctional Flexible Capacitive Sensor for Human Motion Tracking

Guopeng Zhou, Ran Zhao, Hanchen Yao and Houde Dai
Quanzhou Institute of Equipment Manufacturing, Chinese Academy of Sciences, China
Tim C. Lueth
Department of Mechanical Engineering, Technical University of Munich, Germany

- A flexible capacitive sensor based on conductive textiles is developed.
- The sensor is developed for multiple motion tracking tasks, i.e., stretching, pressing, and touching.
- It exhibits sensitivities of $0.21kPa^{-1}$, $0.06kPa^{-1}$ and $0.032Pa^{-1}$ for stretching, pressing and touching, respectively.



Application of the multifunctional sensor

TuB3: Mobile Robots I

Session Chairs: Hesheng Wang and Yang Gao

Room : Nan Shan B, 3/F, 13:00-14:15, Tuesday, December 28, 2021

TuB3(1) 13:00–13:15

Human-Aware Robot Navigation Based on Asymmetric Gaussian Model

Kunxu Zhao, Lei Zhou, Zhengxi Hu, Shilei Cheng, Andong Shi, Yue Sun, Jingtai Liu
Institute of Robotics and Automatic Information System, Nankai University, China

- This paper proposes a navigation framework based on an asymmetric Gaussian model and pedestrian trajectory prediction.
- Using multiple Gaussian functions, the pedestrian speed and gaze direction are modeled, so as to obtain a more humanized comfortable space.
- Human comfort space and predicted trajectory are integrated into the navigation system, so that the robot can produce anthropomorphic trajectory.

TuB3(2) 13:15–13:30

Attacking End-to-End Visual Navigation Model: How Weak Existing Learning-Based Approaches Can Be?

Hongye Wang, Kefan Jin and Hesheng Wang
Department of Automation, Shanghai Jiao Tong University, China

- A FGSM-based attacking method designed by minimizing the maximum value of the visual features
- We solves the problems of branch activation uncertainties and the lack of labels.
- A general adversarial training framework which can overcome the proposed feature space attack.

TuB3(3) 13:30–13:45

Towards Minimally-Intrusive Navigation in Densely-Populated Pedestrian Flow

Tong Zhou[1], Senmao Qi[2], Erli Lyu[2], Guangdu Cen[2], Jiaole Wang[2], and Max Q.-H. Meng[13]
[1]The Chinese University of Hong Kong, Hong Kong
[2]Harbin Institute of Technology (Shenzhen), China
[3]Southern University of Science and Technology, China

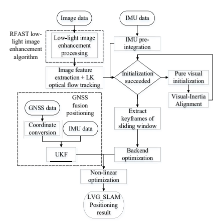
- Flow disturbance penalty and individual disturbance penalty are proposed to handle the macro and micro disturbance.
- Triangle-based sampling strategy is used to find the optimal and minimally intrusive trajectory.
- The results demonstrate that two penalty terms significantly improve the navigating performance in pedestrian flow.

TuB3(4) 13:45–14:00

Research on Driverless Vehicle Positioning Based on Simultaneous Localization and Mapping in Low Visibility Environment

Wangxin Cao, Yang Gao, Hongyao Xia, Sen Kang
Chang'an University, Xi'an, China

- Our task is to improve the positioning accuracy and robustness of VI-SLAM algorithm in a large-scale and low-visibility environment.
- The RFAST image preprocessing module is added to the front end of the algorithm, which improves the contrast of the image while ensuring the details.
- Introduce GNSS positioning information into VI-SLAM to control the degree of error accumulation of the positioning algorithm.
- Results show that LVG_SLAM algorithm has advantages in positioning accuracy and robustness in the face of a large-scale and low-visibility environment.

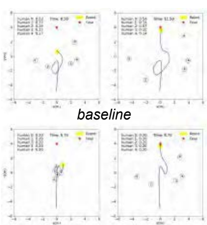


TuB3(5) 14:00–14:15

Human-Aware Robot Navigation via Reinforcement Learning with Hindsight Experience Replay and Curriculum Learning

Keyu Li[1], Ye Lu[1], and Max Q.-H. Meng[1,2]
[1] Department of Electronic Engineering, The Chinese University of Hong Kong, Hong Kong, China
[2] Department of Electronic and Electrical Engineering, Southern University of Science and Technology, China

- In this work, an RL-based approach to efficient and collision-free navigation in a crowded environment is proposed.
- To address the sparse reward human-aware navigation problem, we incorporate the hindsight experience replay (HER) and curriculum learning (CL) techniques with RL to efficiently learn the optimal navigation policy.
- The results show that our method can effectively learn human-aware navigation without requiring additional demonstration data.



baseline

RL+HER+CL (ours)

TuB4: Human-Robot Interaction

Session Chairs: Haibo Yu and Wenyuan Chen

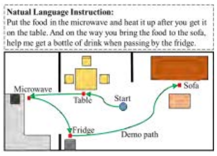
Room : Liang He Room, 3/F, 13:00-14:15, Tuesday, December 28, 2021

TuB4(1) 13:00–13:15

Grounding Language to Natural Human-Robot Interaction in Robot Navigation Tasks

Qingchuan Xu, Yang Hong, Yueyuan Zhang, Wenzheng Chi and Lining Sun
Robotics and Microsystems Center, School of Mechanical and Electric Engineering, Soochow University, Suzhou, China

- A new method to process natural language instructions given to the service is proposed.
- The proposed method does not need any corpus or labeled dataset.
- A NLIP based robot navigation framework is presented.
- Experimental studies demonstrate the effectiveness of the proposed method.



A demonstration path for the robot to navigate based on the natural language instruction.

TuB4(2) 13:15–13:30

A Human-Robot Collaboration System for Object Handover

Yifei Yang, Longzhong Lin, Yifan Zhang, Zhongxiang Zhou, Yue Wang and Rong Xiong
State Key Laboratory of Industrial Control Technology and Institute of Cyber-Systems and Control, Zhejiang University, China.

- Introduce a semi-automatic annotating method to facilitate dataset annotation
- Utilize REDE and Fast-SCNN to achieve fast and accurate pose estimation
- Make use of artificial potential field and admittance control to control robot arm perform a smooth follow-up movement
- Integrate computer vision and motion planning to form a Human-Robot Collaboration system, which can transfer object from robot to human successfully

The experiment platform

TuB4(3) 13:30–13:45

Tempo Synchronization of Physical Activities with a Mixed-Reality Human-Machine-Interface

Sebastian Fernando Chinchilla Gutierrez, Jose Victorio Salazar Luces and Yasuhisa Hirata
Department of Robotics, Tohoku University, Japan

- Multimodal Human Machine Interface for ballroom dance coaching.
- Haptic, auditory, and visual feedback of the reference trajectories and tempo are provided.
- Users exhibited a reduction of position, velocity and synchronization errors during and after the training.

Mixed-Reality Human-Machine Interface

TuB4(4) 13:45–14:00

Learning Robotic Ultrasound Scanning Skills via Human Demonstrations and Guided Explorations

Xutian Deng, Yiting Chen and Miao Li
School of Power and Mechanical Engineering, Wuhan University, China
Fei Chen
Department of Mechanical and Automation Engineering, T-Stone Robotics Institute, The Chinese University of Hong Kong, Hong Kong

- We proposed a learning-based approach to learn the robotic ultrasound scanning skills from human demonstrations.
- The robotic ultrasound scanning skill is encapsulated into a high-dimensional multi-modal model.
- We leverage the power of imitation learning to train the multi-modal model with demonstrated data.
- A post-optimization procedure with guided explorations is proposed to improve the learned model.

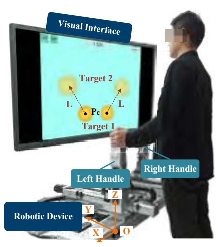
The setup of our robotic ultrasound system.

TuB4(5) 14:00–14:15

Improving Human-Robot Interaction Safety through Compliant Motion Constraints in Bilateral Upper Limb Rehabilitation

Qing Miao, Bin Zhong, Chenyang Sun, Kaiqi Guo, and Mingming Zhang*
Southern University of Science and Technology, China

- This paper contributes to robot-assisted bilateral upper limb rehabilitation via proposing a safety metrics.
- A safe interactive workspace is analyzed based on an end-effector robotic device.
- A compliant strategy that limits the movement inside of the workspace and prevents the handles impacting the boundary of the workspace.



TuB5: Robot Design & Analysis I

Session Chairs: Shan Guo and Hao Liu

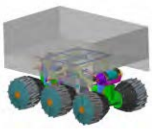
Room : Nan Hai Room, 3/F, 13:00-14:15, Tuesday, December 28, 2021

TuB5(1) 13:00−13:15

Design of Six-Wheeled Planetary Rover with a Novel Hybrid Suspension

Sanfeng Hu and Jianguo Tao
State Key Laboratory of Robotics, Harbin Institute of Technology, China
Guoxing Wang
Beijing Spacecraft, Beijing, China

- A novel hybrid suspension of six-wheeled planetary rover based on serial articulated suspension is proposed.
- The geometric parameters of the hybrid suspension structure are optimized by using NSGA-II.
- Describes the movement strategy of the active mode of the hybrid suspension rover.
- The optimization results and motion strategy of active mode are verified by ADAMS simulation.



Hybrid suspension of six-wheeled rover

TuB5(2) 13:15−13:30

Design and Analysis of a Multi-Section Wire-driven Continuum Robot System with Variable Structures

Yujie Liu, Yue Wan, Shuang Song and Jiaole Wang

School of Mechanical Engineering and Automation, Harbin Institute of Technology(Shenzhen), China.

- Design and analysis of a multi-section wire-driven continuum robot
- Kinematics model with both forward and inverse have been deducted.
- Workspace of the robot tip has been analyzed.

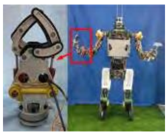
Multi-Section Wire-driven Continuum Robot

TuB5(3) 13:30−13:45

Design and Control of a Hydraulic Driven Robotic Gripper

Jiahui Qi, Xu Li, Zhenguo Tao, Haibo Feng and Yili Fu
State Key Laboratory of Robotics and System, Harbin Institute of Technology, China

- Design of a hydraulic driven three-finger gripper with linkage transmission.
- Kinematics and statics analysis for modeling and simulation.
- Position tracking and large load grasping experiments using PID controller.
- High load to-weight ratio.



The WLRG-I, a novel hydraulic driven gripper using linkage transmission

TuB5(4) 13:45−14:00

Electric Vehicle Automatic Charging System Based on Vision-force Fusion

Dashun Guo, Liang Xie, Hongxiang Yu, Yue Wang and Rong Xiong
College of Control Science and Engineering,Zhejiang University, China

- System: Propose a complete method including perception, planning, and control for the electric vehicle automatic charging system.
- Sensor Fusion: Propose a hybrid vision-force modality for complex manipulation tasks.
- Sim2real: The whole system is trained in simulation and directly transferred to the real world without any fine-tuning

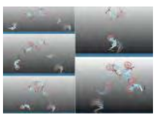
The real experiment configuration

TuB5(5) 14:00−14:15

Design of a Hopping Robot with Its Kinetics and Dynamics Analysis

Yuzhen Pan and Huiliang Shang*
Academy for Engineering and Technology, Fudan University, China

- A newly designed bionic hopping robot Referring to hopping animals on interactive simulation platform
- The hopping procedure with kinetics and dynamics analysis
- Use PID-controlled flywheel for attitude balance in case of rolling over
- Matlab-Adams collaborative simulation platform



The hopping procedure on Adams (before applying PID attitude control)

TuPo2: Poster Session II

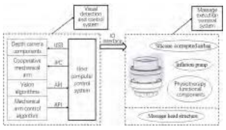
Room : Foyer, 1/F, 14:15-14:35, Tuesday, December 28, 2021

TuPo2(1) 14:15-14:35

Flexible Physiotherapy Massage Robot

Kefan Xing, Diansheng Chen*,
Ruilong Xue and Diwen Wang
Institute of Robotics, Beihang University, China

- The research in this paper designs a structure of flexible physiotherapy massage head.
- The silicone corrugated airbag can present different stiffness according to the input air pressure.
- This paper proposes human back visual recognition algorithm and massage path planning algorithm.

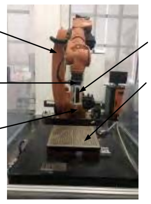


Flexible Physiotherapy Massage Robot Figure Overall Technical Route

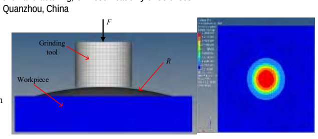
TuPo2(2) 14:15-14:35

Modeling of robot grinding force variation based on curvature-position coupling

Weilong Huang[1,2], Yinhui Xie[2], Yong Yang[2], Jinxing Yang[2], Jun Li [2*]
1. College of Mechanical and Electronic Engineering, Fujian Agriculture and Forestry University
Fuzhou, China
2. Quanzhou Institute of Equipment Manufacturing, Chinese Academy of Sciences
Quanzhou, China



◆ The grinding robot system with force control



◆ ANSYS simulation model ◆ The stress nephogram on workpiece surface

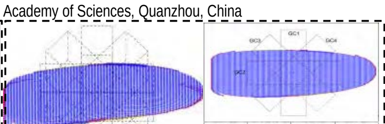
- In order to explore the variation of grinding force during the grinding process, the mechanical model of grinding contact force needs to be developed.
- By combining with the functional relationship between curvature and maximum stress, the applied load should be decreased when the curvature of the workpiece surface increases to make the grinding force keep constant.

TuPo2(3) 14:15-14:35

Object optimal grasping recognition method based on local point cloud model

HuiXiongZeng, NingHuang, YongYang, Jun Li*
Laboratory of Robotics and Intelligent Systems,Quanzhou Institute of Equipment Manufacturing, Chinese Academy of Sciences, Quanzhou, China

◆ Experimental scene



GC1 Score	GC2 Score	GC3 Score	GC4 Score
0.295	0.24	0.01	**0.365**

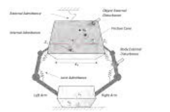
- The closer the contour point set is to the center of the point cloud, the better.
- The smaller the average error between the fitting line and the points, the better.
- The more parallel the short side of the cuboid and the line fitted by the contour point set, the better.
- The more parallel the two lines fitted by two contour point sets captured by a grasp cuboid, the better.

TuPo2(4) 14:15-14:35

Prioritized Hierarchical Compliance Control for Dual-Arm Robot Stable Clamping

Xiaoyu Ren and Liqun Huang
Ubtech Robotics Corp., China.
Mingguo Zhao
Department of Automation, Tsinghua University, China

- Propose a control framework to comply with two types of disturbances simultaneously and hierarchically
- Optimize the internal wrench to ensure stable clamping under stochastic disturbances
- Adopt the object admittance and joint space admittance to realize the compliance control
- Solve the inverse kinematics of the dual-arm robot using hierarchical quadratic programming



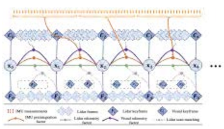
Dual-Arm Robot Clamping Model

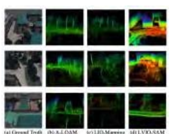
TuPo2(5) 14:15-14:35

LVIO-SAM: A Multi-sensor Fusion Odometry via Smoothing and Mapping

Xinliang Zhong[1], Yuehua Li[1*], Shiqiang Zhu[1], Wenxuan Chen[1], Xiaoqian Li[1], and Jason Gu[1]
Intelligent Robot Research Center of Zhejiang Lab, Hang Zhou, China

- A multi-sensor fusion odometry, LVIO- SAM, which fuses LiDAR, stereo camera and inertial measurement unit (IMU) via smoothing and mapping.
- We take advantage of the measurement results of LiDAR, stereo camera and inertial sensors fuse them in a tightly coupled manner.
- We maintain a sliding window which is updated using lidar and visual odometry rather than observations like edge/plane feature of lidar scans and the tracked visual feature points to streamline the fusion system.
- For more details of experiments, you can visit our github:https://github.com/TurtleZhong/LVIO-SAM and Youtube link: https://youtu.be/ci5QTtYvJAY.





(a) Ground Truth (b) A-LOAM (c) LIO-Mapping (d) LVIO-SAM

TuPo2(6) 14:15-14:35

Automatic steel grabbing robot system for scrap steel processing production line

Rongsheng Wang and Bo Zhou
School of Automation, Southeast University, Nanjing
Yirong Liu
School of Automation, Southeast University, Nanjing

- grabbing robot prototype's hardware architecture
- forward and reverse kinematics analysis
- trajectory planning of joint-space schemes and Cartesian- space schemes for actual
- MATLAB Simulations

TuPo2: Poster Session II (cont.)

Room : Foyer, 1/F, 14:15-14:35, Tuesday, December 28, 2021

TuPo2_2(7) 14:15–14:35

Learning Motor Skills of Reactive Reaching and Grasping of Objects

Wenbin Hu, Chuanyu Yang, Kai Yuan, Zhibin Li
School of Informatics, University of Edinburgh

- A DRL-based framework for reactive **reaching and grasping** of static and moving objects
- A task-orientated reward function, i.e. multiple geometric metrics for object grasping
- Special state initialization to effectively learn recovery skills from grasping failures

Hand-finger motions for grasping a moving object on the ground

TuPo2_2(8) 14:15–14:35

TuPo2_2(9) 14:15–14:35

Force-position perception of soft fingers with variable stiffness based on FBG sensor

Jinen Li, Xiaoliang Shi, Yi Zhang, Haibin Yin*
School of Mechanical and Electronic Engineering, Wuhan University of Technology, China

- The study proposed a soft finger driven by SMA and embed with FBG sensor
- The purpose is to realize the force-position perception of soft fingers when grasping objects
- The method is to predict force-position perception by kinetic model
- The validity of the prediction was verified by comparing experimental, theoretical and simulation results

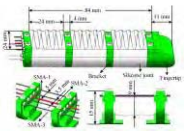


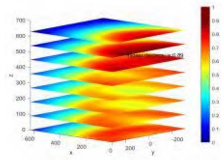
Figure 1. Structure of soft finger

TuPo2_2(10) 14:15–14:35

Dexterous Workspace Analysis of Industrial Robot for Machining Based on Service Sphere

Zhenya He[1,2], Junming Wang[1], Xianmin Zhang[1], Mingjing Song[1], Guojian Huang[3], Jianzhong Fu[2]
[1] Guangdong Provincial Key Laboratory of Precision Equipment and Manufacturing Technology, South China University of Technology, China
[2] The State Key Laboratory of Fluid Power and Mechatronic Systems, Zhejiang University, China
[3] School of Electrical Engineering, Guangdong Mechanical & Electrical, China

- A new expression method of the dexterity index based on service sphere was presented.
- The simulation was carried out on a 6-DOF serial robot to verify the feasibility.
- The suitable machining areas for different machining process of the robot were determined.



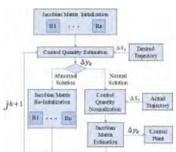
The dexterous workspace analysis for multi-axis machining

TuPo2_2(11) 14:15–14:35

Synchronous Motion Generation of Multiple Continuum Robots Based on a Jacobian-Estimation Strategy

Ning Tan, Ruikun Hu and Yuyang Wu
Sun Yat-sen University, China
Xinyu Zhang
East China Normal University, China
Fenglei Ni
State Key Laboratory of Robotics and Systems (HIT), China
Zhenglong Sun
The Chinese University of Hong Kong, Shenzhen, China

- A novel model-free approach is proposed for the synchronous motion control problem of multiple continuum robots.
- The proposed algorithm is verified through various simulations including cooperative task execution and simultaneous trajectory tracking.
- The proposed algorithm is compared with two model-free algorithms and a model-based one.



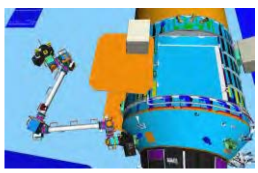
The model-free synchronous motion control method

TuPo2_2(12) 14:15–14:35

Joint Limit Optimal Inverse Kinematics of the 7-DoF Manipulator with Link Offset based on Semi-analytical Solution

Yaowen Zhang, Yechao Liu*, Baoshi Cao, Yang Liu, Boyu Ma and Zongwu Xie
State Key Laboratory of Robotics and System, Harbin Institute of Technology, China

- A semi-analytic inverse kinematic method proposed based on joint parameters
- Joint limits optimization was solved based on the Lagrange multiplier method
- The searching for the optimal fixed joint angle parameters was transformed into root-finding problem and solved by the Newton iteration method
- The closed-form solution has repeatability and high computational accuracy relative to the velocity level inverse kinematics



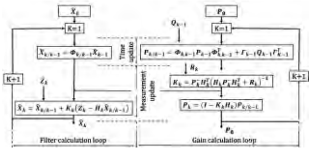
Configuration of the 7-DoF Manipulator on the Space Station

Room : Foyer, 1/F, 14:15-14:35, Tuesday, December 28, 2021

TuPo2_3(13) 14:15-14:35

Towards Automatic Operation Motion Tracking Algorithm Based on Inertial Sensors for Multi Joints Machinery

Yingjiao Rong, Zengshuai Qiu, Jiayi Liu, Zhan Shu, Chen Jiao, Guangyi Shi, and Qiang Qin*



The Kalman filter loops

The setup and experiment process recording

Heavy machinery with multiple armswith rotation motion will change the dimensional coordinates accordingly. Thus, the motion tracking will give the feedback for automatic control and realize the unmanned operation in the end. Inertial measurement units (IMUs) are designed with 6D MEMS sensors. Calibration method is studied and the installation error is corrected. Extend Kalman filter is designed for dynamic motion tracking. The acceleration chip structure is also studied for later on ASIC design.

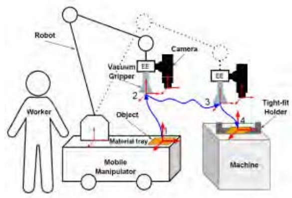
The AISC structure design as a soft core

TuPo2_3(14) 14:15-14:35

Maximizing the Use of Environmental Constraints: A Pushing-Based Hybrid Position/Force Assembly Skill for Contact-Rich Tasks

Yunlei Shi[1,2], Zhaopeng Chen[2,1], Lin Cong[1], Yansong Wu[3] , Martin Craiu-Müller[2], Chunyang Chang[2], Lei Zhang[2], Jianwei Zhang[1]
[1]Department of Informatics, University of Hamburg, Germany
[2]Agile Robots AG, Germany
[3]Technical University of Munich, Germany

- We analyzed the constraint case when the object and the environment have relative motion.
- We proposed a pushing-based hybrid position/force assembly skill.
- We demonstrated that the proposed skill can maximize the utilization of environmental constraints.

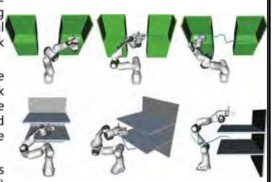


TuPo2_3(15) 14:15-14:35

Manipulator motion planning based on task-space constraint guidance

Wei Chen[1)], Jiangping Wang[2)*], Chenghao Wang[2)], Jun lv[3)]
[1)]Automation Research Institute Co., Ltd. of China South Industries Group, Mianyang, China
[2)]Intelligent Robot Research Center, Zhejiang Lab, Hangzhou, China
[3)]Yiwu Industrial & Commercial College, School of Mechatronics & IT, Yiwu, China

- An algorithm named PCE-BiRRT(Progressive Constraint Extension Bi-direction Rapidly Exploring Random Trees) is proposed in this paper to deal with the manipulator motion planning under task constraints.
- Using task-space guidance and a progressive constraint expansion strategy for satisfying the task constraints. Dealing with "connection failure problem" by limiting the connecting range and choosing a property redundancy resolution for the final smooth path.
- The effectiveness of the PCE-BiRRT algorithm is tested on the robot operating system (ROS) platform by an orientation-constrained case.



TuPo2_3(16) 14:15-14:35

Enhanced Hybrid Position and Admittance Control Based on Nonholonomic Wheeled Mobile Manipulator with Redundancy

Ze Wang, Yuran Wang, Luyao Zhang, Hua Chen, Yang Pan and Wei Zhang
Department of Mechanical and Energy Engineering,
Southern University of Science and Technology, Shenzhen, China

- A control strategy to accomplish hybrid position and admittance control of NWMM with constraints was proposed.
- A method to enhance the force exertion ability under limited joint torque was proposed.
- Experiments on a two-wheeled nonholonomic mobile manipulator verified the feasibility of the proposed control strategy and the superiority of the method is demonstrated.

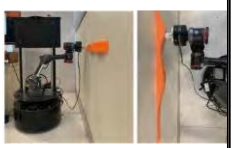


Fig.1 Constant force control of end-effector on curved surface with Nonholonomic Wheeled Mobile Manipulator

TuPo2_3(17) 14:15-14:35

Research on Robot-assisted Accurate Location of Local Craniocerebral Cooling Method

Shiwei Xu[1,3], Jie Li[2], Yang Liao[2], Chongyang Wang[3], Xiuheng Zhang[1], Huisheng Chen[4], and Hao Liu[3,*]
[1]Shenyang Ligong University,Shenyang, China
[2]Shenyang Jianzhu University,Shenyang,China
[3]Shenyang Institute of Automation Chinese Academy of Sciences, Shenyang,China
[4]Northern theater General Hospital,Shenyang,China

- A robot system for brain tissue intervention is designed
- A method of cooling brain tissue using cerebrospinal fluid
- The practical significance is proved by computational fluid dynamics and cooling curve

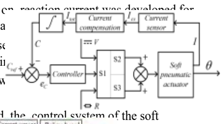
Robot integral system

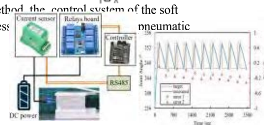
TuPo2_3(18) 14:15-14:35

Deformation control method based on reaction current for soft pneumatic actuator actuated by electrochemical reactions

Yao Xu, University of Chinese Academy of Sciences, Beijing, China
Ting Wang, Shenyang Institute of Automation, Chinese Academy of Sciences, Shenyang, China
Zhidong Wang, Chiba Institute of Technology, Chiba, Japan

- •A deformation control method based on reaction current was developed for the designed soft pneumatic actuator a
- •The current sampled by a current se current loss estimated from the experi
- •The deformation control method show the designed soft pneumatic actuator.
- •With this deformation control method, the control system of the soft pneumatic actuator gets rid of press pneumatic actuator can be easily fabricated.





TuPo2: Poster Session II (cont.)

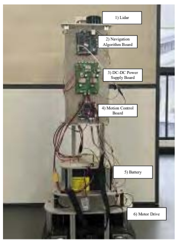
Room : Foyer, 1/F, 14:15-14:35, Tuesday, December 28, 2021

TuPo2_4(19) 14:15-14:35

Design of a Patrol Robot Based on the Plug-In Service Architecture

Chen Jin, Xinggang Fan
Zhijiang College of Zhejiang University of Technology, China
Liyan Chen, and Shujia Qin*
Shenzhen Academy of Robotics, China

- Patrol robots have primarily worked in high-risk scenarios such as power equipment inspection and mining fields
- Surging demand from the market urgently asks for the flexibility of patrol robots' architecture
- This paper introduces a plug-in-based design that adopts a three-layer architecture of hardware-end, back-end, and front-end to realize a patrol robot system with good maintainability and reusability



TuC1: Manipulation II

Session Chairs: Guohui Tian and Kunlong Hong

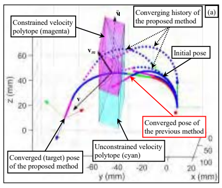
Room : Phoenix Ballroom, 1/F, 14:35-15:50, Tuesday, December 28, 2021

TuC1(1) 14:35–14:50

Manipulability-Oriented Configuration Transition Control of Continuum Surgical Manipulators Based on Velocity Polytopes

Yifan Wang, Yang Zheng, Longfei Wang, and Kai Xu
School of Mechanical Engineering, Shanghai Jiao Tong University, China
Bin Xu
Department of Urology, Shanghai Ninth People's Hospital, China

- The configuration transition inverse kinematics sometimes fails due to the reduced kinematic ability;
- Manipulability along the desired direction is characterized by the constrained velocity polytopes;
- Desired tasks are modified to guide the manipulator towards higher manipulability;
- Failure rate reduced from 5.56% to 0.32%.

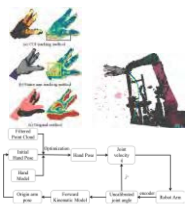


TuC1(2) 14:50–15:05

Towards Components-of-Interest Feedback Control and State Estimation of Robotic Manipulator

Erli Lyu, Zhengyan Zhang, Jiaole Wang, Shuang Song
School of Mechanical Engineering and Automation,
Harbin Institute of Technology (Shenzhen), China
Max Q.-H. Meng
Department of Electronic and Electrical Engineering of the Southern University of Science and Technology in Shenzhen, China

- Track the components-of-interest will accelerate the speed of tracking and improve the tracking precision.
- The end-effector could be moved to specified poses using nominal Jacobian matrix method with high precision while avoiding convex obstacles.
- Using inverse kinematic method could estimate the robot state based on the result end-effector pose.

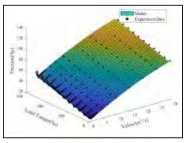


TuC1(3) 15:05–15:20

A Joint Friction Model of Robotic Manipulator for Low-speed Motion

Yimin He, Sheng Bao, Jianjun Yuan and Liang Du
Shanghai Robotics Institute, Shanghai University, China
Shugen Ma
Department of Robotics, Ritsumeikan University, Japan
Weiwei Wan
Graduate School of Engineering Science, Osaka University, Japan

- Based on the Stribeck model, a joint friction model for low-speed motion were proposed
- The model indicates that the joint friction and velocity are nonlinearly related, and the load torque affects the degree of nonlinearity
- The proposed joint friction model can improve the accuracy of the robotic manipulator dynamics model



A joint friction model for low-speed motion

TuC1(4) 15:20–15:35

Disturbance Observer based Fractional-order Control for Free-floating Space Manipulator

Xiangyu Shao, Hao Fu, Ouyang Zhang, Weiran Yao, and Guanghui Sun

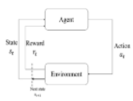
Key Laboratory of Autonomous Intelligent Unmanned Systems,
Harbin Institute of Technology, Harbin, China.

TuC1(5) 15:35–15:50

Review on Reinforcement Learning Controller in Soft Manipulator

Shuopeng Wang, Rixin Wang, Meng Liu,
Ying Zhang and Lina Hao*
School of Mechanical Engineering & Automation,
Northeastern University, Shenyang 110819, China.

- Application of reinforcement learning on soft manipulators is summarized .
- The development prospects for the application of reinforcement learning controllers in soft manipulators are discussed .
- Some feasible methods in use are proposed based on the characteristics of the algorithm in different situations .



TuC2: Robot Design & Analysis II

Session Chairs: Yu Dai and Yaowei Liu

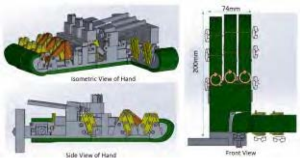
Room : Nan Shan A, 3/F, 14:35-15:50, Tuesday, December 28, 2021

TuC2(1) 14:35–14:50

A Multi-Fingered Robot Hand with Remote Center of Motion Mechanisms for Covering Joints with Soft Skin

Gagan Khullar, Alexander Schmitz, Chincheng Hsu
Prathamesh Sathe, Satoshi Funabashi, Shigeki Sugano
Department of Modern Mechanical Eng., Waseda University, Tokyo, Japan

- Palmar side of the proposed hand is covered 97% with thick skin
- 16 DOFs
- The PIP and DIP coupling is integrated with remote center of motion mechanisms and makes fingers under-actuated
- MCP joint of fingers (except the thumb) includes both flexion/extension and abduction/adduction DOF



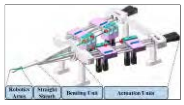
CAD model of robot hand

TuC2(2) 14:50–15:05

Design Optimization of Y-Shaped Transmission System for Dual-Arm Concentric-Tube Robots

Chao Zhang, Guangdu Cen, Xing Yang, Jiaole Wang*
and Shuang Song*
School of Mechanical Engineering and Automation, Harbin Institute of Technology (Shenzhen), China
Max Q.-H. Meng
Department of Electronic Engineering, Southern University of Science and Technology, China

- This paper presents an optimal design framework of Y-shaped transmission system for dual-arm CTR.
- Design constraints including geometric and deformation ones fare deduced.
- The design problem has been formulated as a constrained nonlinear optimization problem.
- A dual-arm CTR prototype with the optimal Y-shaped transmission system has been built.



The CAD model of our dual-arm CTR with Y-shaped transmission system.

TuC2(3) 15:05–15:20

A Novel Modular Wheel-legged Mobile Robot with High Mobility

Qiang Fu, Yisheng Guan*, Shanwei Liu, and Haifei Zhu
School of Electromechanical Engineering,
Guangdong University of Technology, China

- Mobot-H can achieve locomotion in wheeled or legged modes, on continuous or discrete terrains
- Mobot-H may be in different configurations for narrow environments such as small channels
- Mobot-H adapts to inclined surfaces by adjusting the wheel orientation normal to the ground
- Mobot-H can use a flipping-over gait to cross obstacles

Mobot-H adapts to various environments

TuC2(4) 15:20–15:35

Institute of Micro Technology and Medical Device Technology (MIMED)
Prof. Dr. rer. nat. Tim C. Lüth
Departement of Mechanical Engineering
Technical University of Munich

Evaluating clearance parameters of 3D printed joints for the automated design of a non-assembly delta robot

Simon Schiele, The Nghia Nguyen and Tim C. Lüth

IEEE International Conference on Robotics and Biomimetics (ROBIO) 2021

- New non-assembly joint designs for powder-based additive manufacturing
- Measuring appropriate clearance dimensions for different joint sizes and types
- Realising a non-assembly delta robot

TuC2(5) 15:35–15:50

Simulation Platform for Autonomous Aerial Manipulation in Dynamic Environments

Fengyu Quan, Huisheng Huang, Hongjie Zeng, HaoYao Chen
School of Mechanical Engineering and Automation, HIT, China
Yunhui Liu
Department of Mechanical and Automation Engineering, CUHK, China

- Build up a modular simulation platform developed by combining software and hardware models
- Proposed a novel aerial manipulating framework to realize an autonomous remote grasping in cluttered dynamic scenarios
- The proposed approach only relies on onboard sensors, and considers dynamic obstacles existing on the pre-planned path

Aerial manipulation Simulation Platform

TuC3: Robot Learning

Session Chairs: Hongpeng Wang and Liang Zhao

Room : Nan Shan B, 3/F, 14:35-15:50, Tuesday, December 28, 2021

TuC3(1) 14:35–14:50

Training a Robotic Arm Movement with Deep Reinforcement Learning

Xiaohan Ni, Xin He and Takafumi Matsumaru
Graduate School of Information, Production and Systems
Waseda University, Japan

- Introduce a general experimental design scheme for training robotic arm by using DDPG
- Build an interactive reinforcement learning environment for robotic arm control task
- Set two different control tasks to verify the experimental design scheme

two robotic arm control tasks

TuC3(2) 14:50–15:05

A Natural Language Instruction Disambiguation Method for Robot Grasping

Rongguang Ye, Qingchuan Xu, Jie Liu, Yang Hong, Chengfeng Sun, Wenzheng Chi and Lining Sun
Robotics and Microsystems Center, School of Mechanical and Electric Engineering, Soochow University, Suzhou, China

- Natural language instructions with different temporal logic(same semantics)
- Sentence vector similarity calculation model and sentence temporal logic model have been proposed
- Experimental studies demonstrate the effectives of the proposed method

Natural language instructions guide the robotic arm to grasp

TuC3(3) 15:05–15:20

DFNN: Data Fusion Neural Network for Real-scene Reconstruction Model Inpainting of Nature Tree

Hongpeng Wang1,Xiao Han, Zhongzhi Cao, Yaojing Li, and Xinwei Chen
AI school, Nan Kai University , China

➢The experiments demonstrate the feasibility efficiency and effectiveness of our proposed method. Finally, the loss values of the trained generator and discriminator are 0.364 and 0.115 respectively, and the trained generator network inpainting the original model can satisfy the requirement for natural scene reconstruction.

➢In this paper, we propose Data Fusion Neural Network(DFNN) to solve the problem of inpa-inting the natural tree reconstruction model, which is reconstructing inpainting. The DFNN includes a generator network and a discriminator network.

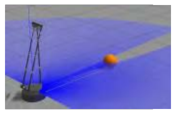
Fig 1. Real scene reconstruction of natural environment.Top is the robot system that performs scanning and reconstruction tasks.Bottom left corner shows the cavity generated by multi-view reconstruction.Bottom right cornershows the inpainting result by DFNN.

TuC3(4) 15:20–15:35

Follow Me: Hierarchical Parallel Execution Synchronization in Behavior Trees

Yongjie Ma , Jiexin Zhang, Yunlong Wu and Yanzhen Wang
Artificial Intelligence Research Center, Defense Innovation Institute, China
Tianjin Artificial Intelligence Innovation Center, China

- Introduce hierarchy into parallel tasks by dividing parallel tasks into leader and follower tasks.
- Propose two new parallel operators to solve the synchronous execution of parallel tasks in BTs.
- Integrate our approach into a popular BT framework and evaluate it by multiple experiments.
- Results show that our approach improves the parallel execution in traditional BT models.



The example of robot following

TuC3(5) 15:35–15:50

YOEO - You Only Encode Once: A CNN for Embedded Object Detection and Semantic Segmentation

Florian Vahl and Jan Gutsche and Marc Bestmann and Jianwei Zhang
Informatics, Universität Hamburg, Germany

- Different outputs needed for *Stuff* (e.g. field, lines) and *Things* (e.g. ball, robot) classes
- Similar input features needed for both detection and segmentation
- Real time inference on embedded hardware
- Shared encoder to combine the feature extraction for both tasks

Application example in RoboCup Soccer

TuC4: System Design & Optimization I

Session Chairs: Yu Dang and Yang Gao

Room : Liang He Room, 3/F, 14:35-15:50, Tuesday, December 28, 2021

TuC4(1) 14:35–14:50

Efficient Inverse Kinematics Optimization Solution Method of Smooth Configuration for Hyper-redundant Robot

Yongqing Wang, Qingzi Yan, Te Li*, Guiben Tuo, Xu Li, Haibo Liu
Key Laboratory for Precision & Nontraditional Machining of Ministry of Education, Dalian University of Technology, Dalian, China

- An efficient inverse kinematics optimization solution method for hyper-redundant robot is proposed.
- The method is proposed to improve the solution efficiency and smoothness of inverse kinematics.
- The orientation accuracy of inverse kinematics is 60% higher than that of traditional PSO algorithms.
- The calculating time is reduced by 90% comparing with the result of pseudo inverse algorithm.

Pseudo inverse PSO experiments

TuC4(2) 14:50–15:05

Design and Analysis of Scissor Extendable Airframe for a Morphing Multirotor

Tao Yang, Peng Li, Yuming Meng
Harbin Institute of Technology Shenzhen, China
Yunhui Liu
The Chinese University of Hong Kong, China

- Presents a general class of symmetric scissor extendable airframes (SEA) with one DOF for adjusting the size of multirotor in flight to various specific tasks and environments.
- Study the influence of design parameters on performance metrics for intuitively obtaining the performance of an SEA and helping design.
- Design and fabricate an SEA to show its morphing response time of 0.5 s, , which enables multirotor to have rapid morphing capability.

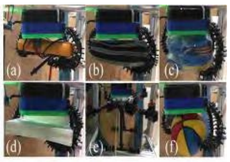
An SEA-enabled morphing quadrotor

TuC4(3) 15:05–15:20

Design and Experiment of a Soft Gripper Based on Cable-Driven Continuum Structures

Qiong Wu, Zhenglong Yi, Hongqiang Wang, Han Yuan*
School of Mechanical Engineering and Automation,
Harbin Institute of Technology Shenzhen, China
Shenzhen Key Laboratory of Biomimetic Robotics and Intelligent Systems, Department of Mechanical and Energy Engineering, Southern University of Science and Technology, Shenzhen, China

- A novel cable-driven soft gripper, the shape and function of which are similar to a human hand was designed.
- Kinematic and kinetic models of the finger are established.
- Simulation analysis and finite element analysis are carried out to optimize the finger.
- Experimental validation proves that the gripper designed can realize stable self-adaptive grasping.



Grasping experiments

TuC4(4) 15:20–15:35

Automated Design of Snap-Fit Joints for the Additive Manufacturing of Robot Links

Samuel Detzel, Nico Besch, Benedikt L. Soballa, Renzo Bazan and Tim C. Lueth
Institute for Microtechnology and Medical Device Technology, Technical University of Munich, Germany

- Automated insertion of snap-fit joints into robot link geometries
- Automated feature recognition and geometric modification using a snap-fit feature library
- Minimized design and assembly effort
- Enabling fast and efficient redesign of additive manufactured robots

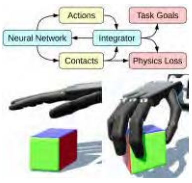
Automatically inserted snap-fit joint

TuC4(5) 15:35–15:50

Direct Policy Optimization with Differentiable Physical Consistency for Dexterous Manipulation

Philipp Ruppel, Norman Hendrich and Jianwei Zhang
Department of Informatics, Universität Hamburg, Germany

- Policy network generates robot control signals and predicts contact points and forces
- Weights are simultaneously optimized to fulfill task goals and to minimize a differentiable physical consistency loss
- Dexterous manipulation tasks can be learned efficiently by single-level gradient-based optimization



TuC5: UAVs I

Session Chairs: Yanding Qin and Xiao Liang

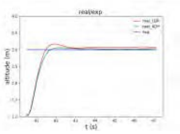
Room : Nan Hai Room, 3/F, 14:35-15:50, Tuesday, December 28, 2021

TuC5(1) 14:35–14:50

Adaptive Optimal Control for the Altitude of the Quadcopter UAV

Jiarun Yan, Xiangke Wang and Yangguang Yu
College of Intelligence Science and Technology, National University of Defense Technology, China

- Study the adaptive optimal altitude control problem of the quadrotor UAV
- The dynamics of altitude is modeled as a linear integrator model with nonlinear model uncertainties
- Design a novel data-driven altitude controller based on the approximate dynamic programming



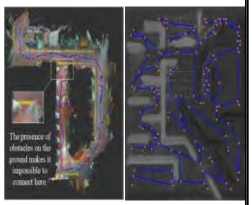
Step response for the altitude control

TuC5(2) 14:50–15:05

2D Topological Map Building by UAVs for Ground Robot Navigation

Yuqian Wang[1], Xuetao Zhang[2], Yisha Liu[3] and Yan Zhuang[1, 2]
[1] Intelligent robotics Laboratory, School of Control Science and Engineering, Dalian University of Technology, Dalian, P. R. China
[2] Intelligent robotics Laboratory, School of Artificial Intelligence, Dalian University of Technology, Dalian, P. R. China
[3] School of Information Science and Technology, Dalian Maritime University, Dalian, P. R. China

- The UAV reconstructs the ground environment from the air view and generates the Euclidean Signed Distance Field (ESDF).
- The traversable topology map of ground robots is constructed at an optional height in the ESDF.
- The accuracy and portability of the method are verified in the simulation environment.



Experimental results

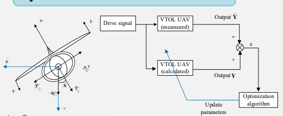
TuC5(3) 15:05–15:20

Data-driven Parameter Estimation for VTOL UAV Using Opposition-Based Pigeon-Inspired Optimization Algorithm

Mengzhen Huo, Haibin Duan*, *Senior Member, IEEE*, Hangxuan He, and Chen Wei

IEEE ROBIO 2021, Sanya, China, Dec.7- Dec. 9, 2021

Dynamic Model of VTOL UAV



$$\begin{cases} -m\ddot{X} = -T\sin\theta + \varepsilon_0 l\cos\theta \\ -m\ddot{Y} = T\cos\theta + \varepsilon_0 l\sin\theta - mg \\ I_x\ddot{\theta} = l \end{cases}$$

- frame of identification structure

$$J = \sum_{i=1}^{N}\frac{1}{2}(y_i - \hat{y}_i)^T(y_i - \hat{y}_i)$$

Opposite-based PIO(OBPIO)

- Deterministic OBL strategy

$$P = Min + (Max - Min)\cdot \text{rand}$$
$$OP_{i,j} = Max_j + Min_j - P_{i,j}$$

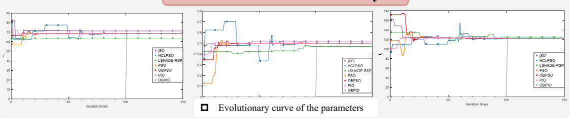
- Dynamic OBL strategy

$$\mathbf{X}_{\text{center\_new},j} = Gaussian(\mu,\sigma^2)\cdot(a_j - b_j) - \mathbf{X}_{\text{center},j}$$
$$\sigma = \sigma_{\min} + (\sigma_{\max} - \sigma_{\min})\cdot(1 - \frac{n}{N})$$

- Complexity Analysis

$$T_{OBPIO} = O(N_c(DN_P + N_P\log N_P))$$

Simulation Results and Analysis



- Evolutionary curve of the parameters

BUAA Bio-inspired Autonomous Flight Systems Research Group 北航仿生自主飞行系统研究组

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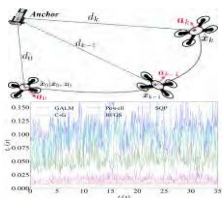
TuC5(4) 15:20–15:35

A Computationally Efficient Moving Horizon Estimation for Flying Robots' Localization Regarding a Single Anchor

Yuzhu Li, Yuanjiong Ying, Wei Dong
School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai, China

- A method based on moving horizon estimation (MHE), which is built on an implemented optimization objective, is proposed for a flying robot's positioning;
- A novel algorithm named gradient aware Levenberg-Marquardt (GALM) is proposed to improve the computation efficiency and realize the real-time solution for the objective.

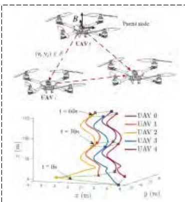


TuC5(5) 15:35–15:50

Geometric Formation Tracking of Aerial Robot Swarms Without Linear Velocity Measurements Over Directed Networks

Jie Lin, Yaonan Wang, and Zhiqiang Miao
College of Electrical and Information Engineering, Hunan University, China.
Rafael Fierro
Department of Electrical and Computer Engineering, University of New Mexico, USA.

- The main contribution of this work is to provide a solution for the formation tracking of the quadrotor UAV swarm without linear velocity measurements over the directed networks.
- The filter-like auxiliary dynamic system is designed for each quadrotor to overcome the lack of the linear velocity measurements.
- The designed almost-global geometric attitude controller is the strongest possible controller in terms of the region of convergence.



Quadrotor formation

Technical Sessions

Wednesday, December 29

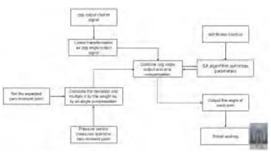
WePo3: Poster Session III

Room : Foyer, 1/F, 10:40-11:00, Wednesday, December 29, 2021

WePo3(1) 10:40-11:00

Stable Walking of Seven-link Biped Robot Based on CPG-ZMP Hybrid Control Method

Jianjun Yu, Yixin Liu, Ruiqi Li, Guoyu Zuo,Naigong Yu



The Central pattern generator (CPG) method has good biomimetic effect, so it is used in the walking research of biped robot. However, the CPG control method has the disadvantage of unstable walking during the walking process of biped robot. To solve this problem, this paper proposes a hybrid control method for biped robot walking based on the CPG and Zero moment point (ZMP).Based on the physical model of the seven-link biped robot, the foot pressure sensor obtains the robot zero moment point in real time, according to the difference between it and the expected zero moment point, realizes the compensation of the CPG output joint angle, and realizes closed-loop control during walking.The parameters in the hybrid control method were optimized by GA optimization algorithm. This paper uses a self-built seven-link biped robot for simulation verification under the VREP simulation platform. The research results show that the hybrid control method can ensure a good bionic effect while achieving stable walking of the robot, and is controlled by a single CPG compared with the method, the hybrid control method can make the walking of the biped robot more stable.

WePo3(2) 10:40-11:00

Self-propulsion of Robotic Dolphin Based on Cooperative Kinematics of Superimposed Fin Module

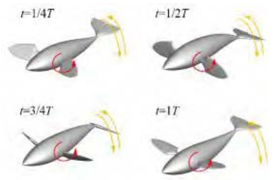
*Zhihan Li, Jiabo Cao, Guangzong Yang and Dan Xia**

Southeast University

(1)This paper proposes a robotic dolphin that relies on cooperative kinematics of superimposed fin module to achieve autonomous propulsion.

(2)The results show that under the condition of the same frequency, the superimposed fin module of pectoral fin assisted caudal fin propulsion is not conducive to improving the forward effect.

(3)The high-frequency swinging rigid pectoral fin can achieve a faster steady-state propulsion speed than the single-fin movement mode.

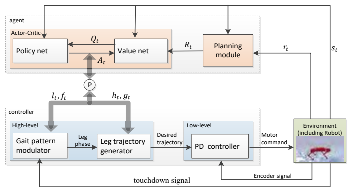


WePo3(3) 10:40-11:00

A learning-based control approach for blind quadrupedal locomotion with guided-DRL and hierarchical-DRL

Liang Ren[1], Chunlei Wang[1], Ya Yang[1] and Zhiqiang Cao[2]

1. The 21st Research Institute of China Electronics Technology Group Corporation, Shanghai, China.
2. The State Key Laboratory of Management and Control for Complex Systems, CASIA, Beijing, China.



- A learning-based control method is proposed, where the parameters of controller are learned by deep reinforcement learning (DRL).
- In the learning process, the guided-DRL and the hierarchical-DRL were used to solve the exploration problem and reward sparse problem, respectively.
- The proposed method can realize blind quadrupedal locomotion on terrains with robustness and energy efficient.

WePo3(4) 10:40-11:00

Control of Robotic Joint Actuated by Antagonistic Pneumatic Artificial Muscles based on Model-free Reinforcement Learning

Haoxuan Li, Daoxiong Gong and Jianjun Yu

Abstract—

With its unique intrinsic flexibility and muscle-like output force characteristics, Pneumatic Artificial Muscle (PAM) has gained important applications in the driving of Coexisting-Cooperative-Cognitive Robots (Tri-Co Robots). However, due to the severe non-linear characteristic caused by the difficulty of accurately modeling of PAM, model-based control methods are not easy to achieve ideal control results. Therefore, this paper proposes a Model-free Reinforcement Learning (RL) method to control a bionic single joint actuated by antagonistic PAMs. We design the angle tracking, angle positioning and variable stiffness experiments of the robot joint, and achieve satisfactory human-like motion effects. The research in this paper can effectively improve the control performance of robotic joint actuated by antagonistic PAMs, thereby improving the accuracy, compliance and safety of the motion control of Tri-Co Robots.

WePo3(5) 10:40-11:00

Vision-based Navigation for a Small-scale Quadruped Robot Pegasus-Mini

G. Deng, J. Luo, C. Sun*, D. Pan, L. Peng, N. Ding and A. Zhang
Shenzhen Institute of Artificial Intelligence and Robotics for Society (AIRS), The Chinese University of Hong Kong (CUHK), Shenzhen 518172, China
*Corresponding author, Dr. Caiming SUN, cmsun@cuhk.edu.cn

- Implementation of a vision-based navigation using se-mantic segmentation on a lightweight computing architecturedeployed on a small-scale quadruped robot .
- Trajectory compensation method is proposed to enhancethe success rate of the vision-based navigation for quadrupedlocomotion.

Quadrupedal robot Pegasus-Mini is running in garden

WePo3(6) 10:40-11:00

Bionic robotic fish attitude detection based on the limiting filtering-extended Kalman filtering algorithm

Qunhong Tian, Tao Wang, Xiaosheng Wei, Liang Yuan and Yunxia Wang

Abstract— Bionic robotic fish is one of the important equipment for marine resources exploration in recent years, as the key link of position control for bionic robotic fish, attitude detection is the basis for bionic robotic fish to complete the complex exploration tasks. In order to solve the problem of robotic fish attitude detection, it needs to implement the data fusion based on the obtained original data from accelerometer, magnetometer, gyroscope. However, it's a nonlinear system for robotic fish attitude detection in practice, and it may occur abnormal data deviation caused by the system external interference or internal disturbance from the sensors, to solve this problem, in this paper, it proposes the limiting filtering-extended Kalman filtering (LF-EKF) algorithm, which combines the limiting filtering (LF) and extended Kalman filtering (EKF) algorithms to realize the data fusion and complete the attitude detection. The simulation results show that the proposed algorithm can obtain the results with good performance.

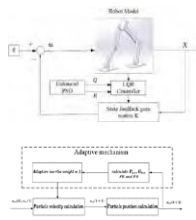
Key words— Bionic robotic fish; attitude detection; extended Kalman filtering; limiting filtering

Room : Foyer, 1/F, 10:40-11:00, Wednesday, December 29, 2021

WePo3_2(7) 10:40–11:00

Research on Disturbance of Upright Balance of Biped Humanoid Robot Based on AWPSO-LQR

Jianjun Yu, Ruiqi LI, Daoxiong GONG, Yixin LIU and Peng LIU



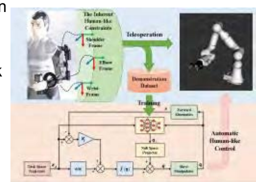
On the premise of ensuring the safety of the biped humanoid robot, this paper focuses on the issue of dynamic balance anti-interference in its upright state. Considering the impact of model accuracy on system performance, it is abstracted as a seven-link model, and the multi-body dynamic model of the single-leg support phase in the sagittal view is established from the energy point of view. And then, based on the above model, a control architecturefull state LQR controller is designed. On the basis of the traditional particle swarm algorithm(PSO), the adaptive inertia weighting scheme based on the success rate of updating the particle velocity, that is, the adaptive weighted PSO(AWPSO) is used to determine the optimal weight matrix of LQR. The simulation experiment results show that the controller can restore the biped humanoid robot from a variety of different initial postures and stabilize it near the upright balance position in a short time, it has a wide dynamic range and does not need to change the controller parameters, the algorithm complexity is also considerably reduced. In addition, our controller has good suppression ability for instantaneous interference.

WePo3_2(8) 10:40–11:00

A Learning from Demonstration Method for Generating Human-like Actions on Redundant Manipulators

Liang Zhao, Peng Yu, Tie Yang, Yang Yang and Lianqing Liu
State Key Laboratory of Robotics, Shenyang Institute of Automation, Chinese Academy of Sciences, China
Ning Xi
Emerging Institute of Technologies and the Department of Industrial and Manufacturing Systems Engineering, The University of Hong Kong, Hong Kong

- A posture-mimicry-featured teleoperation interface for intuitive motion teaching and demonstration data collection
- A human-in-the-loop learning framework that can directly extract human-like features from demonstration.
- An efficient online relabeling approach that can relieve the workload of the human operator in the demonstration session.



WePo3_2(9) 10:40–11:00

Fast and Compliant Whole Body Control for Gear-Driven Torque Sensorless Quadruped Robot Trotting

B. Jin, C. Sun*, D. Cheng, S. Ye, J. Su, A. Zhang
Shenzhen Institute of Artificial Intelligence and Robotics for Society (AIRS), The Chinese University of Hong Kong (CUHK), Shenzhen 518172, China
*Corresponding author, Dr. Caiming SUN, cmsun@cuhk.edu.cn

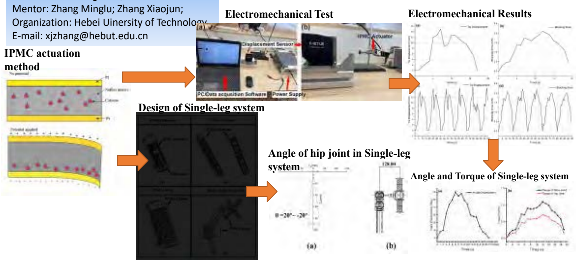
- A whole body control algorithm is proposed to generate the force model that can keep the robot balance during locomotion.
- A QP solver is utilized to distribute the force model to each joint.
- The hybrid force and position control is adopted in the low-level controller, to realize the variable stiffness control and improve the joint position tracking performance.
- A trajectory generator is used to plane the torso trajectory using SLIP.

Quadrupedal robot Pegasus II

WePo3_2(10) 10:40–11:00

Design of Quadruped robot single-leg system by Ionic polymer metal composites actuators array

Lecturer: Mr. Wang Man;
Mentor: Zhang Minglu; Zhang Xiaojun;
Organization: Hebei Uinersity of Technology
E-mail: xjzhang@hebut.edu.cn

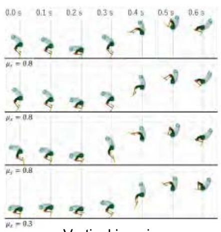


WePo3_2(11) 10:40–11:00

Motion Acquisition of Vertical Jumping by a Bio-inspired Legged Robot via Deep Reinforcement Learning

Shinji Yamaguchi, Ryuki Sato and Aiguo Ming
The Department of Mechanical Engineering and Intelligent Systems, The University of Electro-Communications, Japan

- The purpose is to make a bio-inspired legged robot learn a dynamic motion.
- DRL was used to learn vertical jumping and to acquire its general controller.
- The general controller was acquired by randomizing initial posture and environmental parameters during training.
- DRL enabled the robot to jump in various situations and to skillfully use dynamics.



Vertical jumping in various situations

WePo3_2(12) 10:40–11:00

Mechanical modeling of parallel muscles and guidance for actuation of manipulator

Jiayi Xu[1], Kangjia Fu[2], Yiyong Huang[1], Hongwei Liu[1] and Xiang Zhang[1]
[1] National Innovation Institute of Defense Technology, Academy of Military Sciences
[2] National Innovation Institute of Defense Technology

WePo3: Poster Session III (cont.)

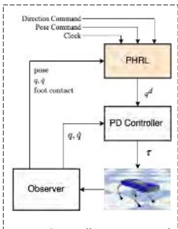
Room : Foyer, 1/F, 10:40-11:00, Wednesday, December 29, 2021

WePo3_3(13) 10:40−11:00

Learning a Push-Recovery Controller for Quadrupedal Robots

Peiyang Li, Wei Chen, Xinyu Han and Mingguo Zhao
Department of Automation, Tsinghua University, China

- We proposed a novel learning framework PHRL to resolve prioritized multi-objective problems.
- We utilized PHRL to learn a controller capable of push-recovery for quadrupedal robots.
- PHRL controller notably reduced robot's position error under external disturbance.
- PHRL learned faster than vanilla RL algorithms.



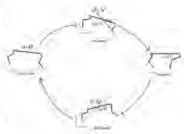
PHRL Controller Framework

WePo3_3(14) 10:40−11:00

Influences of Pitch Angle for a Quadruped Robot in Bounding Gait

Jinyue Cao, Jun Gu, Mingzhe Chen, Andre Rosendo
School of Information Science and Technology
ShanghaiTech University
Shanghai, China

- Inspired by real life animals who position their torso specifically to gain acceleration before pouncing, we add a non-zero pitch angle for mini-Cheetah.
- A trigonometric function is applied to model the periodic desired pitch angle in each gait cycle.
- Our new design reaches a 40% higher maximum velocity than the original algorithm, points to the possibility of improving the velocity of legged locomotion with minor changes in the initial states of a robot.

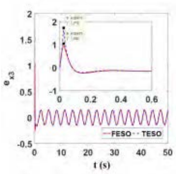


WePo3_3(15) 10:40−11:00

A Fuzzy ESO-based Joint Angle Control Design of Snake Robots

Lili Wu[1], Yang Liu[2], Junfang Zhou[3], Zhigang Wang[1], Yushuang Wang[1], and Yongchen Tang[4]
[1] Beijing Electro-Mechanical Engineering Institute, 100074 Beijing, China
[2] 91039 Army, China
[3] School of Electrical and Information Engineering, Tianjin University, Tianjin, China.
[4] Key Lab of Intelligent Data Information Processing and Control of Hebei Province, Tangshan University, Tangshan, China

1) The joint angle control of snake robots is designed based on FESO.
2) The peaking phenomenon caused by initial estimation errors can be suppressed in the proposed FESO.
3) The effectiveness of the designed joint angle controller is verified by simulations.

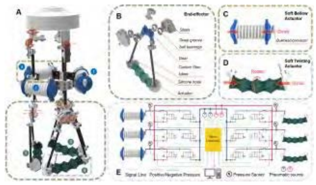


WePo3_3(16) 10:40−11:00

A Soft Gripper Driven by Bellow Actuators and Twist Actuators for Dexterous Grasping

Diancheng Li[1], Liangmin Zhou[1], Renjie Zhu[1], Jintao Yin[1], Zhengbai Liu[1], Han Yuan[2] and Hongqiang Wang[1]
[1] Southern University of Science and Technology, China
[2] Harbin Institute of Technology (Shenzhen), China

- Capable of both adaptive grasping and in-hand manipulation.
- Successful grasping on more than 15 daily items.
- Robustly grabbing an object while experiencing strong impacts.



Overview of the structure and driving system of the soft gripper

WePo3_3(17) 10:40−11:00

An Efficient Motor Synergy-based Control Strategy for Human Arm-like Robot

Hengyu Man[1], Dan Xiong[1], Yiyong Huang[1] and Wei Han
[1] National Innovation Institute of Defense Technology, Academy of Military Sciences

WePo3_3(18) 10:40−11:00

An Underwater Soft Claw Based on Bionic Principle

Sun Yanxu, Fei Han[1], Daohui Zhang, Xingang Zhao and Dan Ye
[1] Shenyang Institute of Automation, CAS

WeA1: Planning & Control I

Session Chairs: Yu Dang and Wenyuan Chen

Room : Phoenix Ballroom, 1/F, 11:00-12:30, Wednesday, December 29, 2021

WeA1(1) 11:00–11:15

Camera Lens Dust Detection and Dust Removal for Mobile Robots in Dusty Fields

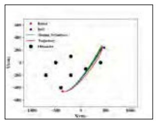
Jalaluddin Mohd Ansari Shajahan[1], Sandra Mamani Reyes[1] and Jizhong Xiao[1]
[1] City College of New York, City University of New York, New York, USA

WeA1(2) 11:15–11:30

Fast and Efficient Trajectory Generation for Ball Interception Using Motion Primitives

Haoran Ren, Kaihong Huang and Zhiqian Zhou
Robotics Research Center,
College of Intelligence Science and Technology,
National University of Defense Technology, China

- A motion-primitive-based trajectory generation method for RoboCup MSL competition.
- A set of constraints are designed for appropriate ball-interception behaviours.
- Low computation, good obstacle-avoidance and real-time performance.

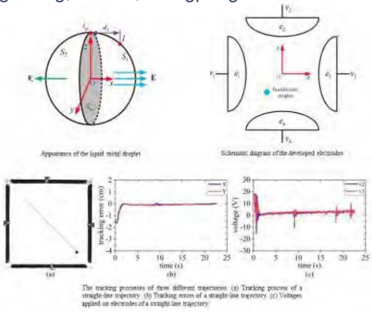


Trajectory of our method in the ball interception task

WeA1(3) 11:30–11:45

Modeling and Control of Liquid Metal Droplet in a two-dimensional Free Space

Erlong Wang, Jie Xie, Xiangpeng Li and Shiwu Zhang



WeA1(4) 11:45–12:00

A Feature Reserved Teaching Method for Pick-Place System under Robot Operating System

Wei Du and Cheng Ding
School of Mechanical Engineering, Shanghai Jiao Tong University, China
Jianhua Wu* and Zhenhua Xiong
School of Mechanical Engineering, Shanghai Jiao Tong University, China

- The method keeps valuable features during the human demonstration and utilizes only one depth camera.
- A marker-less vision-based object tracking using HSV threshold technique is developed.
- The key features in the demonstration trajectory are extracted from angle information calculated among the adjacent waypoints.

Key features extraction

WeA1(5) 12:00–12:15

Model-Predictive Optimization for Lane Keeping Assistance System with Exponential Decay Smoothing

Sheng Zhang and Xiangtao Zhuan
School of Electrical and Automation, Wuhan University, China
Yating Fang
School of Transportation Science and Engineering ,
Civil Aviation University of China, China
Jun Cheng
CAS Key Laboratory of Human-Machine IntelligenceSynergy Systems,
Shenzhen Institute of Advanced Technology, CAS, China

- A lane keeping control strategy that can achieve smooth steering operation is proposed
- With the model predictive control (MPC), the control strategy for lane keeping is designed.
- A reference trajectory in the form of an exponential decay function is set for the performance variables

WeA1(6) 12:15–12:30

Bionic Water Hydraulic System of Soft Robot Control Inspired by Spider Limbs

Siqing Chen[1], He Xu[1] and Xueshan Zhou[1]
[1] Harbin Engineering University

WeA2: Underwater Robots

Session Chairs: Xiao Liang and Han Yuan

Room : Nan Shan A, 3/F, 11:00-12:30, Wednesday, December 29, 2021

WeA2(1) 11:00–11:15

Investigation on Yaw Stability of Bionic Propulsion in Flow Field

Guanwen Chen, Yuhan Li, Jiayong Chen, Ruxu Du, Yong Zhong
Shien-Ming Wu School of Intelligent Engineering,
South China University of Technology, China

- The dynamic model of fish undulatory propulsion is constructed, considering the influence of flow field.
- The influence of rotation center position on the yaw stability of robotic fish is explored.
- The difference of yaw stability between bionic propulsion and screw-propeller propulsion is compared.

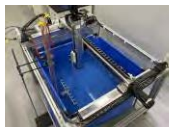
Bionic propulsion robotic fish prototype

WeA2(2) 11:15–11:30

Direction Identification of Underwater Moving Target with Active Electrosense and CNN

Haoran Peng, Qiao Hu, Guangyu Jiang, Dan Xu
and Tongqiang Fu
Department of Mechanical Engineering, Xi'an Jiaotong University, China

- Bio-inspired by weakly electric fish that discharge and sense electrical information
- Active electrosense array with vertically arranged transmitters and sensors
- CNN is used for the direction identification of underwater radial moving target
- Average identifying accuracy reached 84.72% and comparative experiments of sensor quantity were carried out



The detection system of underwater active electrosense

WeA2(3) 11:30–11:45

Mechanism Design, Kinematics and Hydrodynamics Simulation of a Novel Rocker Driving Bionic Robot

Zhongyin Zhang and Liwei Shi
The Ministry of Industry and Information Technology, Beijing Institute of Technology, China

- As shown in Fig.1, the characteristic mechanical structure of this paper mainly lies in three parts, Angle adjustment structure, crank and rocker mechanism and drive structure.
- The trajectory of crank is analyzed and the speed simulation is carried out.
- In this chapter, two analytical methods are proposed based on hydrodynamic simulation. These two methods complement each other and can provide reference for fin shape design.

Figure 1. The overall structure

WeA2(4) 11:45–12:00

Underwater Moving Object Localisation Based on Weak Electric Fish Sensing Principle and LSTM

Guangyu Jiang, Qiao Hu, Haoran Peng, Yu Liu, Sihu Li
and Tongqiang Fu
School of Mechanical Engineering, Xi'an Jiaotong University, China

- Inspired by the biological sensing principle of weak electric fish
- Cylindrical underwater active electric field detection sensor array
- LSTM network with 6-layer architecture for moving object localisation
- The 2dmae is 5.38mm and 2dmre is 1.06% from pool experiment

The underwater active electric field detection pool experiment

WeA2(5) 12:00–12:15

Tracking Strategy of Robotic Fish Based on Multi-Sensor Distributed Detection Information Fusion

Youdong Chen, Jiawei Yang and Yong Zhong
Shien-Ming Wu School of Intelligent Engineering, South China University of Technology, China

- This paper adopts a low-cost infrared sensor with scarce sensing information as the primary sensor.
- We present the target tracking strategy is based on multi-sensor distributed detection information fusion.
- Several sets of experiments are conducted to verify the effectiveness and robustness of the strategy.

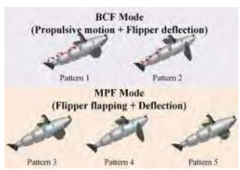
The design of robotic fish

WeA2(6) 12:15–12:30

Turning Maneuverability Analysis of a Bionic Gliding Robotic Dolphin

Yang Zhang, Zhengxing Wu, Jian Wang and Min Tan
The State Key Laboratory of Management and Control for Complex Systems, Institute of Automation, Chinese Academy of Sciences, China

- A novel gliding robotic dolphin with a special yaw joint is developed to purse high turning maneuverability.
- Five turning patterns are selected to explore how the special mechanism as well as some key parameters affect the turning performance of the robotic dolphin.
- Various simulations are carried out to analyze the turning capability. The obtained results validate the effectiveness of these turning patterns for the bionic gliding robotic dolphin.



WeA3: EMG

Session Chairs: Ningbo Yu and Bo Zhu

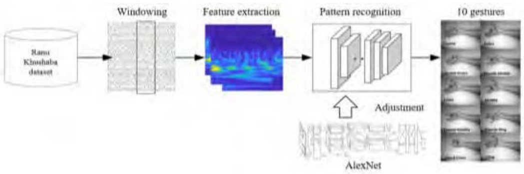
Room : Nan Shan B, 3/F, 11:00-12:30, Wednesday, December 29, 2021

WeA3(1) 11:00-11:15

An Approach for sEMG-based Gesture Recognition using Continuous Wavelet Transform and AlexNet Convolutional Neural Network

Ke Zhu, Hongcheng Liu, Yiwei Xiong, Xiaodong Zhang, Yingjie Zhang
School of Mechanical Engineering, Xi'an Jiaotong University, Xi'an, China

Chen He
AVIC Creative Robotics Co., Ltd, Xi'an, China



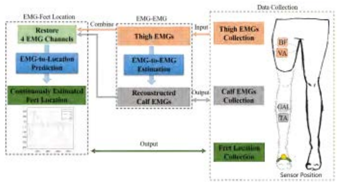
- A CWT-AlexNet model was proposed to realize gesture recognition.
- Based on Rami Khushaba EMG repository, the approach allows 99.95% classification accuracy for 10 gestures.

WeA3(2) 11:15-11:30

Improved Gait Posture Prediction in Transfemoral Amputees with Reconstructed Shank EMG Signals

Wensi Zhang[1], Xingchao Wang[2,3], Xiyuan Zhang[1], and Zhenglong Sun[2,3]
[1] School of Life and Health Sciences, The Chinese University of Hong Kong, Shenzhen.
[2] School of Science and Engineering, The Chinese University of Hong Kong, Shenzhen.
[3] Shenzhen Institute of Artificial Intelligence and Robotics for Society (AIRS), China.

- Address the problem for transfemoral amputees: the lack of EMGs in the amputated part of the body poses a challenge in gait posture prediction
- Reconstruct shank EMGs from thigh EMGs to augment input data
- Confirm that the prediction system with augmented EMGs (reconstructed shank EMGs + actual thigh EMGs) recovers 95.28% of the performance on average, comparing to prediction systems using both thigh and shank EMGs.

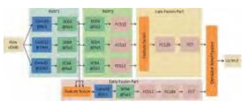


WeA3(3) 11:30-11:45

A Convolutional Neural Network With Multi-scale Kernel and Feature Fusion for sEMG-based Gesture Recognition

Lijun Han, Yongxiang Zou and Long Cheng
Institute of Automation, Chinese Academy of Sciences, China
School of Artificial Intelligence, University of Chinese Academy of Sciences, China

- A Multi-scale Kernel and Feature Fusion Convolutional Neural Network (MKFF-CNN) is proposed.
- MKFF-CNN was evaluated on both the gForce dataset and the Ninapro DB6.
- MKFF-CNN achieves 97.65% accuracy on the gForce dataset, better than all the subnetworks.
- MKFF-CNN achieves 98.52% accuracy on the Ninapro DB6, 1.3% higher than the state-of-the-art works.



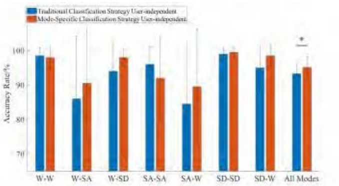
The architecture of MKFF-CNN model

WeA3(4) 11:45-12:00

A Mode-Specific Classification Based on sEMG for User-Independent Locomotion Transition Recognition

Ziyao Wang, Xingwei An, Rui Xu*, Lin Meng and Dong Ming
Tianjin University, Tianjin, China

- The mode-specific classification strategy was used to distinguish seven locomotion modes, including four different transitions, and improved the accuracy significantly.
- The user-independent recognition was discussed. The recognition accuracies of the proposed strategy was 95.14% with user-independent method.
- Further, the user-dependent and user-independent classification strategies from the thigh achieved accuracies of over 95% and 80%, respectively.

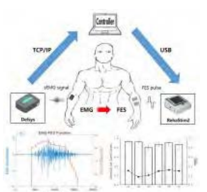


WeA3(5) 12:00-12:15

A Real-time sEMG-based Control Strategy and System for Contralaterally Controlled Functional Electrical Stimulation

Xinyu Zhao, Ziyao Wang, Rui Xu* Dong Ming
Tianjin University, Tianjin, China

- Contralaterally controlled functional electrical stimulation has been proven to be effective in improving hand dexterity
- The sEMG-based control strategy can be better used during grasping objects and bearing weights
- This algorithm divides the function into three segments according to the sEMG under different forces
- Three out of six subjects' correlation coefficients of the joint angles of the two wrists is greater than 0.9



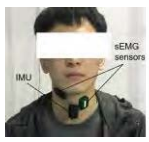
CCFES control strategy and system

WeA3(6) 12:15-12:30

An sEMG-based Hill-type Model for Estimation of Swallowing Motion

Zhenhui Guo,Song Zhang,Yu Dang,Ningbo Yu and Jianda Han
College of Artificial Intelligence, Nankai University, China
Yue Wang,Jinqiao Wu,Yang Yu and Jialing Wu
Department of Rehabilitation Medicine, Tianjin Huanhu Hospital,China

- sEMG has been used for screening dysphagia but rarely for estimating swallowing motion
- The sEMG signals and acceleration signals representing swallowing motion were collected simultaneously and preprocessed
- The Hill-type model based on sEMG was established to estimation swallowing motion
- The experiments tested 4 healthy subjects to verify the proposed method



Schematic representation of sensors

WeA4: SLAM

Session Chairs: Guangyi Shi and Shan Guo

Room : Liang He Room, 3/F, 11:00-12:30, Wednesday, December 29, 2021

WeA4(1) 11:00–11:15

Collaborative Radio SLAM for Multiple Robots based on WiFi Fingerprint Similarity

Ran Liu, Zhenghong Qin, Hua Zhang, Billy Pik Lik Lau, Khairuldanial Ismail, Achala Athukorala, Chau Yuen, Yong Liang Guan, and U-Xuan Tan
Southwest University of Science and Technology,China and Singapore University of Technology and Design, Singapore

- We propose the collaborative radio SLAM to optimize the trajectory using a multiple-robot scenario based on fingerprint similarity.
- A new similarity measure that combines the received signal strength and the detection likelihood of the access point is proposed.
- Experiments are performed to validate the proposed similarity measure and our proposed collaborative SLAM solution.

Overview of our collaborative radio SLAM with two robots.

WeA4(2) 11:15–11:30

Robust Indoor Visual-Inertial SLAM with Pedestrian Detection

Heng Zhang, Ran Huang, Liang Yuan
College of Information Science & Technology, Beijing University of Chemical Technology, China

- A system built on ORB-SLAM3 with pedestrian detection
- Combining dynamic SLAM with the visual-inertial fusion, our system can achieve better robustness.
- A real-time dynamic SLAM algorithm with parallel tracking thread and segmentation thread

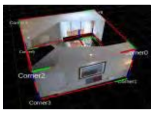
Features detected by ORB-SLAM3 and our method

WeA4(3) 11:30–11:45

Low-Drift RGB-D SLAM with Room Reconstruction Using Scene Understanding

Zefeng Ye and Yun-hui Liu
T Stone Robotics Institute, The Chinese University of Hong Kong, China
Xin Jiang
Department of Mechanical Engineering and Automation, Harbin Institute of Technology, China

- An efficient scene understanding method to detect wireframes and layout planes of building from RGB-D image.
- The global features (wireframes and layout planes) are integrated with point-based SLAM to improve the accuracy and robustness.
- A geometrically more meaningful map can be obtained from the proposed SLAM system.



The geometric SLAM map with wireframes and layout planes.

WeA4(4) 11:45–12:00

Construction Robot Localization System Based on Multi-sensor Fusion and 3D Construction Drawings

Xiang Li[1], Xin Jiang[1]*, Yunhui Liu[2]
[1]Harbin Institute of Technology (Shen Zhen), China
[2]The Chinese University of Hong Kong, China

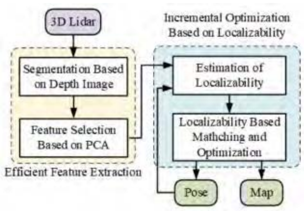
- We use multi-sensor fusion and 3D construction drawings to conduct global localization and position tracking.
- We propose an image-driven point cloud segmentation pipeline to filter the point cloud.
- We use unscented Kalman filter to fuse the point cloud registration pose with IMU.
- This system achieves higher accuracy than LiDAR SLAM localization.

WeA4(5) 12:00–12:15

Efficient Feature Extraction and Localizability Based Matching for Lidar SLAM

Lingfeng Dong[1], Weidong Chen[1], Jingchuan Wang[1]
[1]Medical Robotics and Department of Automation, Shanghai Jiao Tong University, China

- A lidar SLAM system for mobile robot running in feature sparse and degraded environments.
- A stable feature selection method based on PCA.
- Localizability is used to estimate the localization performance of robot and dynamically adjust the matching prameters.

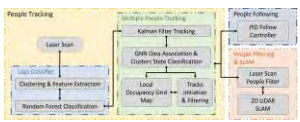


Algorithm architecture

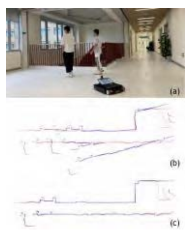
WeA4(6) 12:15–12:30

Mapping While Following: 2D LiDAR SLAM in Indoor Dynamic Environments with a Person Tracker

Hanjing Ye, Guangcheng Chen, Yisheng Guan
Biomimetic and Intelligent Robotics Lab (BIRL), Guangdong University of Technology
Weinan Chen, Li He, and Hong Zhang
Electronic and Electrical Engineering, Southern University of Science and Technology



- A framework combining people tracking and following with dynamic object removal in 2D LiDAR SLAM
- Real world experiments show that this framework is effective in handling dynamic objects and reducing the mapping error.



WeA5: Soft Robots

Session Chairs: Chaoyang Shi and Yong Jiang

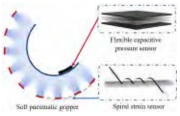
Room : Nan Hai Room, 3/F, 11:00-12:30, Wednesday, December 29, 2021

WeA5(1) 11:00–11:15

A Soft Pneumatic Gripper Integrated with a Flexible Capacitive Pressure Sensor

Rui Liu, Jianxiong Hao, Xiaoyang Li, He Su, Chaoyang Shi
Key Laboratory of Mechanism Theory and Equipment Design of Ministry of Education, School of Mechanical Engineering, Tianjin University, Tianjin, China

- A flexible pressure sensor was proposed to be integrated on a soft pneumatic gripper
- The flexible pressure sensor can detect the interaction force of the soft pneumatic gripper
- The soft pneumatic grippers were used to perform grasping capacity test



The soft bending module with flexible sensing element

WeA5(2) 11:15–11:30

A Q-learning Control Method for a Soft Robotic Arm Utilizing Training Data from a Rough Simulator

Peijin Li[1], Gaotian Wang[2], Hao Jiang[1], Yusong Jin[1], Yinghao Gan[1], Xiaoping Chen[1], and Jianmin Ji[1]
[1] The School of Computer Science, University of Science and Technology of China
[2]The School of Physical Science, University of Science and Technology of China

- A **Q-learning** controller for a physical soft robot;
  - With **pre-trained models** using data from a rough simulator;
- experiments with our physical soft robot, HPN Arm;
  - Pre-trained models can **reduce the amount of the real-world training data**;
  - Pre-trained models can also greatly **improve accuracy and convergence rate**;

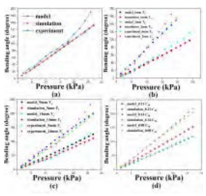
The HPN Arm controlled in this work

WeA5(3) 11:30–11:45

Modeling, analysis and design of pneumatic networks soft actuators

Tong Liu[1,2], Xuan Wu[1], and Xiaojie Wang[1*]
[1]Institute of Intelligent Machines, Hefei Institutes of Physical Science, Chinese Academy of Sciences, China
[2]University of Science and Technology of China, China

- This paper propose a theoretical model for pneumatic networks soft actuators (PNSAs) by considering the geometric complexity and nonlinear deformation of the structure.
- The model can accurately predict the bending angles of different PNSAs. We investigate the effects of geometric and material parameters on structural bending. A computational code of the model has been implemented into design analysis, which provides a convenient and effective tool for the design of PNSAs.



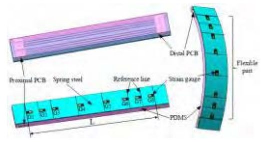
Comparison of model, simulation and experiment.

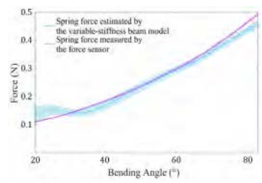
WeA5(4) 11:45–12:00

Shape and Force Sensing of A Soft SMA Planar Actuator for Soft Robots

Yiming Ouyang, Hu Jin, Haoyao Chen, Jingwen Kong, Weihua Li, Shiwu Zhang

- An SMA planar actuator (SPA) with a strain gauge array sensing system
- A shape sensing method and a variable-stiffness beam model are proposed to realize the shape and one-dimensional external force sensing
- A shape reconstruction experiment and a force sensing experiment of a variable external force were implemented and the results validated the effectiveness and the accuracy of the above sensing methods



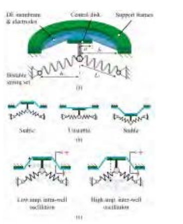


WeA5(5) 12:00–12:15

A novel insect-inspired 'clicking' dielectric elastomer oscillator for soft robotics

Lijin Chen and Weiwei Zhao
School of Mechanical and Electronic Engineering, Wuhan University of Technology, China
Chongjing Cao, Lei Wang and Xing Gao
Research Centre for Medical Robotics and Minimally Invasive Surgical Devices, Shenzhen Institute of Advanced Technology (SIAT), China

- A bistable dielectric elastomer oscillator (DEO) inspired by the flying insects was developed.
- The bi-stability and resonant actuation jointly lead to the high output of the DEO.
- This DEO shows superior power output performance than the monostable counterpart in lightly damped conditions.
- This design can have promising applications in bio-inspired robotics, energy harvesters, etc.



WeA5(6) 12:15–12:30

Manipulability and Robustness Optimization of the Cable-Driven Redundant Soft Manipulator

Yi Shen[1], Yang Hong[1], Wei Zhou[1], Ruochen Tai[2], Ye Yuan[1,3,4,*], Han Ding[3,4]

1. School of Artificial Intelligence and Automation, Key Laboratory of Image Processing and Intelligent Control, Huazhong University of Science and Technology,430074 Wuhan, People's Republic of China.
2. School of Electrical and Electronic Engineering, Nanyang Technological University, 50 Nanyang Avenue, Singapore, 639798, Singapore.
3. School of Mechanical Science and Engineering, Huazhong University of Science and Technology, 430074 Wuhan, People's Republic of China.
4. State Key Lab of Digital Manufacturing Equipment and Technology, Huazhong University of Science and Technology, 430074 Wuhan, People's Republic of China.

- **Contributions**
  - A manipulability optimization method together with the inverse-kinematics analysis of the 4-DOF cable-driven soft manipulator in order to avoid kinematics singularity.
  - This work further considers the control noise of the actuator input and introduces such noise constrains with the manipulability to optimization scheme for obtaining a robust inverse-kinematics solution.
  - The proposed manipulability and robustness optimization controller:

$$\begin{aligned} \min \quad & \|\dot{\boldsymbol{q}}(k)\|_2^2 + \|\triangle \mathbf{J}(k)\|_2^2 - \lambda \boldsymbol{\eta}^T \dot{\boldsymbol{q}}(k) , \\ \text{s.t.} \quad & \boldsymbol{q}_{min} \le \boldsymbol{q}(k+1) \le \boldsymbol{q}_{max} , \\ & \boldsymbol{q}(k+1) = \boldsymbol{q}(k) + \dot{\boldsymbol{q}}(k) , \\ & \mathbf{J}\dot{\boldsymbol{q}}(k) = \dot{\boldsymbol{x}}_c(k) + \mathbf{K}\boldsymbol{e}(k) . \end{aligned}$$

- **Experiment results**

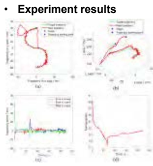


Fig. 1 The result of s-curve tracking based on *pseudo-inverse kinematics controller*. (a) Trajectory projected on x-y plane. (b) Trajectory in 3D space. (c) Trajectory error. (d) Manipulability.

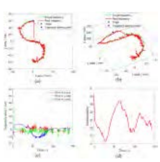


Fig. 2 The result of s-curve tracking based on *the proposed optimization based controller*. (a) Trajectory projected on x-y plane. (b) Trajectory in 3D space. (c) Trajectory error. (d) Manipulability.

WeB2: Mobilization & Learning

Session Chairs: Hesheng Wang and Liang Zhao

Room : Nan Shan A, 3/F, 13:30-15:00, Wednesday, December 29, 2021

WeB2(1) 13:30–13:45

A Survey on Deep-Learning Approaches for Vehicle Trajectory Prediction in Autonomous Driving

Jianbang Liu, Xinyu Mao, Yuqi Fang, Delong Zhu
CUHK, China
Max Q.-H. Meng
Electronic Eng., CUHK, China & Electrical and Electronic Eng., SUST, China

In this work, we survey some recent approaches for vehicle trajectory prediction and present some inno- vative ideas.

The two main contributions are as follows:

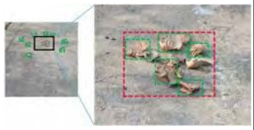
- 1) Recent deep-learning approaches tackling trajectory prediction problems in driving scenarios are reviewed and discussed.
- 2) We implement the prediction model introduced by Zhao et al. and release our code to the research community.

WeB2(2) 13:45–14:00

NMF: an Efficient Method for Detecting the Fallen Leaves Using Cleaning Robots on the Road

Yanzi Miao and Zongwei Zhang
School of Information and Control Engineering,
China University of Mining and Technology, China
Hesheng Wang
Department of Automation, Shanghai Jiao Tong University, China

- To deal with the dense leaves detection problem and improve navigation efficiency, we propose a **Non-Maximum Fusion(NMF)** algorithm.
- The experiments on the fallen leaves data set shows that NMF **improves the fallen leaves detection coverage significantly**.
- NMF greatly **reduces the number of goal nodes** for path planning.



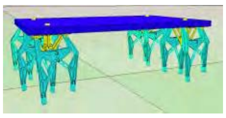
For the green detection boxes, they do not cover all dense leaves and give too many goal nodes to path planning module. But for the red, it almost covers all leaves and only needs to plan path once.

WeB2(3) 14:00–14:15

Adaptive Locomotion Control of Sixteen-legged Robot based on Deep Reinforcement Learning

Xixi Mu, Shibo Shao, and Dong Zhang
College of Information Science and Technology, Beijing University of Chemical Technology, China

- The robot learns to move at speed of 14 ~ 17 m/s on a flat ground.
- The robot learns to locomote smoothly with a 350 kg load.
- The robot learns to traverse up on a slope of 40° from a plane.
- The robot learns to traverse down on a slope of 45° from a plane.



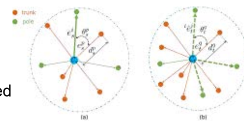
The model of the sixteen-legged robot

WeB2(4) 14:15–14:30

Pole-like Objects Mapping and Long-Term Robot Localization in Dynamic Urban Scenarios

Zhihao Wang, Silin Li, Ming Cao, Haoyao Chen*
Mechanical Engineering and Automation, Harbin Institute of Technology Shenzhen, China
Yunhui Liu
Mechanical and Automation Engineering, Chinese University of Hong Kong, China

- A method to extract semantic cluster from raw 3D LiDAR points and create semantic cluster map.
- A semantic cluster association algorithm based on geometric consistency is proposed to relocalize in long-term scenarios.
- A long-term and real-time localization system is developed based on the robust semantic cluster relocalization module.

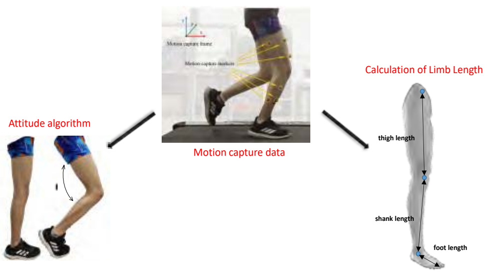


Semantic Cluster Associaton diagram

WeB2(5) 14:30–14:45

Attitude Algorithm and Calculation of Limb Length Based on Motion Capture Data

Authors: Nianfeng Wang*, Jiegang Huang, Fan Yue and Xianmin Zhang



WeB3: Dynamics & Control I

Session Chairs: Houde Dai and Yu Dai

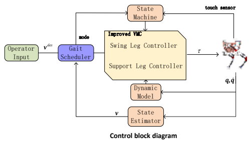
Room : Nan Shan B, 3/F, 13:30-15:00, Wednesday, December 29, 2021

WeB3(1) 13:30–13:45

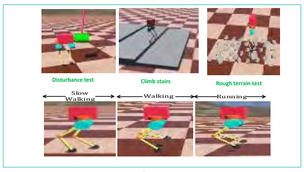
Highly Dynamic Bipedal Locomotion via an Improved Virtual Model Algorithm (40)

Zhengguo Zhu, Weiliang Zhu, Zhongkai Sun, Yibin Li, Xuewen Rong and Guoteng Zhang

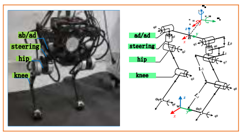
In this paper, we propose a new virtual model control(VMC) algorithm combining inverse dynamic control and optimization. We have shown how our approach significantly improves the dynamic performance of biped robots with point feet and, thus, enables the point-footed robot with excellent stability and high-speed movement ability.



Control block diagram



Algorithm verification



Degree of freedom configuration

WeB3(2) 13:45–14:00

Following Evaluation Index System for Service Robots in Dynamic Environments

Yue Sun, Meng Liu and Jingtai Liu*
Institute of Robotics and Automatic Information System and Tianjin Key Laboratory of Intelligent Robotics, Nankai University, China

- This paper proposes an evaluation index system of robot comfortable following.
- The method improves the psychological comfort of the followed human and other pedestrians .
- Service robots can show human-like social behaviors, which increases the degree of robots communicating with human and will be more acceptable to humans.


Comfortable Following Evaluation Index System

WeB3(3) 14:00–14:15

A Novel Hopping Height Controller with Positive Velocity Feedback for Hydraulic Actuated Legged Robot

Yan Yuan, Ce Li, Bo Gu, Mengtang Li, Beichen Ding*
School of Intelligent Systems Engineering, Sun Yat-sen University, China

- This paper proposes a novel hopping height controller with positive velocity feedback for hydraulic legged robot.
- The proposed controller significantly reduces the number of measured variables without detecting the ground contact.
- Conditions for self-excited hopping are theoretically derived and it is successfully demonstrated via simulation using SYSU-HOPPER legged robot model.

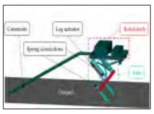


Figure. The 3D prototype of bipedal hopping robot

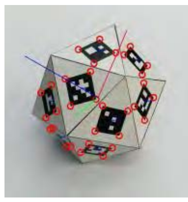
WeB3(4) 14:15–14:30

The Icosahedron Marker for Robots 6-Dof Pose Estimation

Lunhui Duan, Hao Sun, Bokai Xuan, Yinglun Tan, Rui Cui and Mengkun Wu
School of Artificial Intelligence, Hebei University of Technology, China

- An improved monocular 6D pose estimation method based on the spatial icosahedron.
- Achieve translation accuracy of sub-millimeter level and rotation accuracy of less than 1°. Besides, it realized the ±180° large-scale rotation detection of three axes, and the real-time indicators is also satisfied.

- Higher Accuracy
- Higher detection stability
- Can cope with large changes in pose.

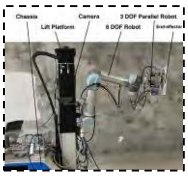

Icosahedron Marker

WeB3(5) 14:30–14:45

Putty Plastering Realized by a Force Controlled Robotic Scraper

Liu Zhao, Chen Dayuan and Jiang Xin
School of Mechanical Engineering and Automation, Harbin Institute of Technology, Shenzhen, China
Liu Yunhui
Department of Mechanical Engineering, The Chinese University of Hong Kong, Hong Kong, China

- We propose a putty plastering strategy based on a force controlled scraper which is mounted at the end-effector of an interior finishing robot.
- In order to control the quality of putty plastering, we verified several strategy including active parameters adjustment of impedance control, active adjustment of scraper speed/tilt angle.
- The plastering experiments in a construction site proved that the evenness and coated putty thickness can meet the quality requirements.



Robot Platform

WeB3(6) 14:45–15:00

An Adaptive Force Control Architecture with Fast-Response and Robustness in Uncertain Environment

Xin Shu, Fenglei Ni, Kang Min, Yechao Liu and Hong Liu
The State Key Laboratory of Robotics and System, Harbin Institute of Technology (HIT), Harbin, Heilongjiang, China

- It has the capability to compensate for environmental uncertainties.
- The experiments of tracking constant/variable desired force in constant/variable stiffness environment and on an unknown shape surface are carried out.
- The results comparison confirms that the proposed control law is superior in fast-response and robustness in uncertain environments.

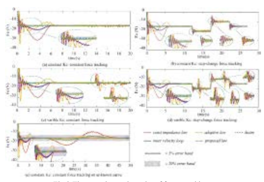


Fig.3 The experimental results of force tracking.

Fig.1 Experimental setup .

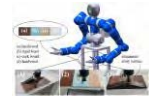


Fig.2 The snapshots of experimental scenarios.

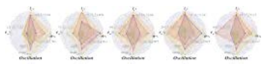


Fig.4 The performance comparison of experiments.

WeB4: Legged Robots

Session Chairs: Yong Jiang and Hao Liu

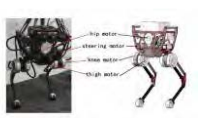
Room : Liang He Room, 3/F, 13:30-15:00, Wednesday, December 29, 2021

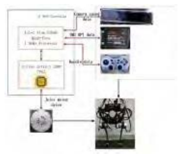
WeB4(1) 13:30–13:45

Design of BRAVER - a bipedal robot actuated via proprioceptive electric motor

Weiliang Zhu, Zhengguo Zhu, Xuewen Rong, Yibin Li and Guoteng Zhang

This paper provides a system overview about BRAVER, a **lightweight bipedal robot** designed for fast moving. BRAVER stands above 0.5 m tall, weighs approximately 6 kg, and features 8 torque-controlled joints **powered by proprioceptive electric motor** well-distributed on two legs. This paper describes design and implementation of robot and presents details on **hardware system** such as microcontroller, actuation and sensor. Several experiments were carried out to prove that the bipedal robot could execute position and torque tracking robustly.





WeB4(2) 13:45–14:00

Design and Analysis of the Leg Configuration for Biped Robots' Spring-like Walking

Ruilong Du[1,2], Sumian Song[1], Shiqiang Zhu[1], Daming Nie[1], Fangyan Shen[1], Haihui Yuan[1,2], Jason Gu[3] and Mingguo Zhao[2]

1. Intelligent Robot Research Center, Zhejiang Lab, China
2. Department of Automation, Tsinghua University, China
3. Department of Electrical Engineering, Dalhousie University, Canada

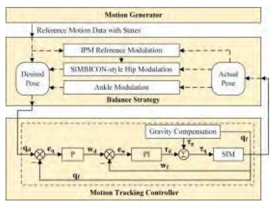
- This work presents a compliant leg configuration that satisfies SLIP model-based control.
- A numerical model was introduced to analyze the kinematics and the stiffness of the designed leg.
- Numerical analysis showed that the leg could be taken as a variable stiffness.
- Experiments were conducted on the leg prototype to verify the analysis of the stiffness.

WeB4(3) 14:00–14:15

Towards a more practical data-driven biped walking control

Zhiyan Cao, Tianxu Bao, Wenchuan Jia*, Shugen Ma and Jianjun Yuan
School of Mechatronics Engineering and Automation, Shanghai University, Shanghai, China

- This control framework achieves a robust performance while closely keeps the style of the data.
- Decent bipedal action simulated by a balance strategy and a motion tracking controller.
- A cascaded position-velocity control with gravity compensation proposed for motion tracking control.



WeB4(4) 14:15–14:30

Agile Control For Quadruped Robot In Complex Environment Based on Deep Reinforcement Learning Method

Hua Xiao, Shibo Shao and Dong Zhang
College of Information Science and Technology, Beijing University of Chemical Technology, China

- In this paper, a hierarchical training framework based on DPPO algorithm is proposed to solve complex tasks of quadruped robot.
- To assist the training of DPPO, different open-loop signals are introduced into the low-level network.
- The fact that high-level networks can receive different low-level strategies for completing tasks is also an advantage of our network's structure.

Using our reinforcement learning framework to accomplish different complex tasks.

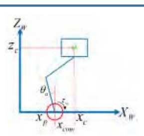
WeB4(5) 14:30–14:45

Whole-body Motion Planning and Control for Underactuated Wheeled-bipdal Robots

Yu Wang, Yaxian Xin, Xuewen Rong and Yibin Li
Shandong University

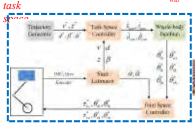
According to the dynamic analysis of the wheeled inverted pendulum model (WIPM), the horizontal posture x_{com} is introduced into the torso pose to establish the kinematics with the torso pose as the task space.

$$\ddot{x}_c = \frac{g}{z_c}(x_c - x_p) = \frac{g}{z_c} x_{com}$$

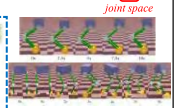


The whole-body Jacobian (***WBJ***) matrix is derived to establish the speed relationship between ***the task space*** and ***the joint space***

$$\underbrace{\boxed{\begin{bmatrix} \dot{\hat{x}}_{com} \\ 0 \\ \dot{\hat{z}}_{com} \\ \dot{\hat{d}} \\ \dot{\hat{\beta}}_{com} \\ 0 \end{bmatrix}}}_{task\ space} = \underbrace{\begin{bmatrix} -(l_1c_a^l + l_2c_{ak}^l)/2 & -l_2c_{ak}^l/2 & 0 & -(l_1c_a^r + l_2c_{ak}^r)/2 & -l_2c_{ak}^r/2 & 0 \\ -(l_1c_a^l + l_2c_{ak}^l) & -l_2c_{ak}^l & 0 & l_1c_a^r + l_2c_{ak}^r & l_2c_{ak}^r & 0 \\ -(l_1s_a^l + l_2s_{ak}^l)/2 & -l_2s_{ak}^l/2 & 0 & -(l_1s_a^r + l_2s_{ak}^r)/2 & -l_2s_{ak}^r/2 & 0 \\ -(l_1s_a^l + l_2s_{ak}^l) & -l_2s_{ak}^l & 0 & l_1s_a^r + l_2s_{ak}^r & l_2s_{ak}^r & 0 \\ 1/2 & 1/2 & 1/2 & 1/2 & 1/2 & 1/2 \\ 1 & -1 & 1 & -1 & 1 & -1 \end{bmatrix}}_{WBJ} \underbrace{\boxed{\begin{bmatrix} \dot{\theta}_{la} \\ \dot{\theta}_{lk} \\ \dot{\theta}_{lh} \\ \dot{\theta}_{ra} \\ \dot{\theta}_{rk} \\ \dot{\theta}_{rh} \end{bmatrix}}}_{joint\ space}$$



control frame



The snapshot of simulation

WeB5: BCI

Session Chairs: Yuliang Zhao and Bo Zhu

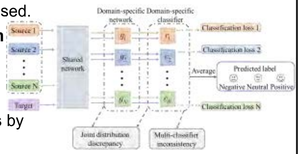
Room : Nan Hai Room, 3/F, 13:30-15:00, Wednesday, December 29, 2021

WeB5(1) 13:30–13:45

Joint Distribution Adaptation Network for Multi-source Electroencephalogram-based Emotion Recognition

Ying Tan, Gan Liu and Feng Duan
Department of Intelligence Science and Technology, Nankai University, China
Lingfeng Chen
School of Mathematics and Statistics, Xi'an Jiaotong University, China
Zhe Sun
Computational Engineering Applications Unit, RIKEN, Japan

- A **JDAN** model for **multi-source EEG-based emotion recognition** is proposed.
- The model includes **joint distribution alignment** and **multi-classifier alignment.**
- The model **estimates the similarity** between **source** and **target domains** by using joint distribution discrepancy.
- The model shows good performance in **cross-subject experiment** and **cross-day experiment**.



The framework of the JDAN model

WeB5(2) 13:45–14:00

A brain-computer interface based semi-autonomous robotic system

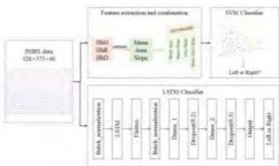
Dongcen Xu, Yixuan Tong, Xuyang Dong, Cong Wang, Liangqing Huo, Yiping Li, Qifeng Zhang and Xisheng Feng
Shenyang Institute of Automation, Chinese Academy of Sciences

WeB5(3) 14:00–14:15

fNIRS Feature Extraction and Classification in Grip-Force Tasks

Jinrui Liu, Ting Song, Zhilin Shu, Jianda Han, Ningbo Yu*
College of Artificial Intelligence, Nankai University, China
Tianjin Key Laboratory of Intelligent Robotics, Nankai University, China
Institute of Intelligence Technology and Robotic Systems, Shenzhen Research Institute of Nankai University, China

- fNIRS measures brain activities in cortex and is of increasing research interest in study of brain function.
- fNIRS feature extraction and classification methods are investigated for grip-force tasks.
- The results demonstrate the feasibility and potential of fNIRS-based decoding of motor tasks.

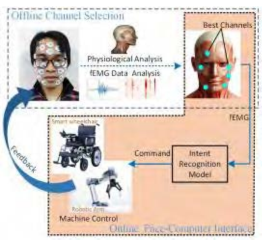


fNIRS signal processing and classification pipeline

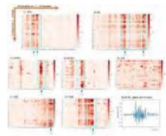
WeB5(4) 14:15–14:30

A Novel Limbs-free Human-Computer Interface: Face-Computer Interface (FCI) with Channels Optimization

Bo Zhu, Daohui Zhang, Yaqi Chu and Xingang Zhao
Shenyang Institute of Automation, CAS



FCI Frame



FCI offline channels optimization

FCI control robotic arm for drinking water

WeB5(5) 14:30–14:45

Analysis of Psychological Structure in Mass Sense for Object Lifting Operation.

Kazunori Kodama, Kai Kondo, Yuta Namekata, Ryojun Ikeura , Shigeyoshi Tsutsumi, and Soichiro Hayakawa
Graduate school of Engineering, Mie university,

Abstract

●The subject of this study was the mass sense related to the lifting operation of a power-assisted device.

●We prepared an experimental setup that simulated the power-assisted device. The experiment consisted of a lifting operation with one vertical degree of freedom. The purpose of the study was to identify the psychological structure of the subject when the mass predicted by the subject differed from the mass actually lifted by the subject due to the generation of assist force. We adopted the semantic differential method for psychological evaluation.

●As a result of the experiment, we derived that the psychological structure of the sense of mass related to the lifting operation has an index of "stability" in the first place and an index of "comfort" in the second.

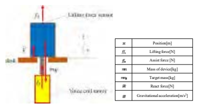


Fig 2. Parameters used for description of motion equations

Fig 3. The operation of the subject

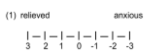


Fig 5. Example of a questionnaire (7 levels of answers)

WePo4: Poster Session IV

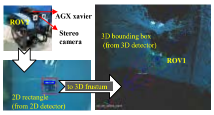
Room : Foyer, 1/F, 15:00-15:30, Wednesday, December 29, 2021

WePo4(1) 15:00–15:30

An Efficient Lightweight 2D Driven 3D Detector for Underwater Robots Tracking

Lu Chen, Zhengjia Zhu, Caiming Sun, and Aidong Zhang
Peng Cheng Laboratory (PCL), Shenzhen 518055, Guangdong, China
Shenzhen Institute of Artificial Intelligence and Robotics for Society (AIRS), the Chinese University of Hong Kong (CUHK), Shenzhen 518172, China

- A 2D driven 3D object detection and tracking framework was proposed.
- The proposed detection and tracking pipeline are lightweight and is easily as well as rapidly deployed on an underwater robot.
- The pipeline achieved both high accuracy and high robustness in underwater robot leader-follower dynamic formation experiments.



Two underwater robots are tracking each other using 2D driven 3D detector and tracking pipeline.

WePo4(2) 15:00–15:30

A Novel Sensor Fusion Method Based on Invariant Extended Kalman Filter for Unmanned Aerial Vehicle

Xuan Zhou[1,2], Yi Chen[1], Yaohua Liu[2], Jinxing Hu[2,*]
Email:jinxing.hu@siat.ac.cn

The paper proposes a sensor fusion method based on Invariant Extended Kalman filter (InEKF) with left invariant error (LIEKF) for UAV localization in MATLAB, which inertial measurement unit (IMU) data is used for prediction and GPS data is used for correction.

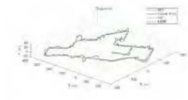


TABLE I
COMPARISON OF STANDARD DEVIATION BETWEEN EKF AND LIEKF

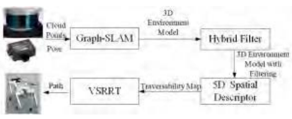
Method	Standard Deviation Error		
	Xerror	Yerror	Zerror
EKF	100.3107	126.8364	8.1871
LIEKF	100.2341↓	126.7528↓	8.1250↓

WePo4(3) 15:00–15:30

Autonomous Legged Robot Navigation with Environment Awareness System in Complex Outdoor Environments

Jiamin Guo, Guanglin Lu, Teng Chen, Xuewen Rong, Yibin Li, Zhiying Wang, Haoning Zhao, Jialin Zhang
School of Control Science and Engineering, Shandong University, China

- The hybrid filtering algorithm can effectively reduce the data scale.
- The 5D space descriptor extracts more abundant topographic information.
- The VSSRRT could obtain a short path under the condition of fast convergence.



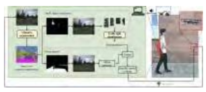
The Environment Awareness System of Autonomous Legged Robot

WePo4(4) 15:00–15:30

Flying Guide Dog: Walkable Path Discovery for the Visually Impaired Utilizing Drones and Transformer-based Semantic Segmentation

Haobin Tan, Chang Chen, Xinyu Luo
Jiaming Zhang, Constantin Seibold, Kailun Yang, Rainer Stiefelhagen
CV:HCI, Karlsruhe Institute of Technology, Germany

- Propose a "flying guide dog" prototype utilizing drone and semantic segmentation for visually impaired assistance
- Develop a control algorithm to enable the drone to fly along the walkable path automatically
- Introduce Pedestrian and Vehicle Traffic Lights (PVTL) dataset for traffic lights recognition

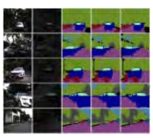


WePo4(5) 15:00–15:30

NLFNet: Non-Local Fusion Towards Generalized Multimodal Semantic Segmentation

Ran Yan, Kaiwei Wang
State Key Laboratory, Zhejiang University, China
Kailun Yang
Institute for Anthropomatics and Robotics, Karlsruhe Institute of Technology, Germany

- NLFNet, which is a semantic segmentation network that effectively integrates multimodal image data
- Our network adaptively extracts complementary features of different modal input images
- We conduct extensive experiments on different multimodal datasets and comprehensively analyze the effectiveness



Qualitative result comparison between different networks

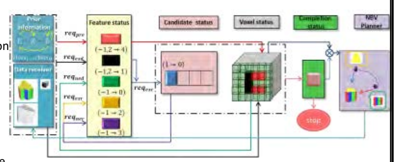
WePo4(6) 15:00–15:30

A Generic View Planning Algorithm Based on Formal Description of Perception Tasks

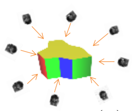
Yanzi Kong, Feng Zhu, Haibo Sun, Qun Wang and Zhiyuan Lin

Formal description of a task:

- Prior information library
  - Features' prior information
  - Candidate library
- Perception status
  - Feature status
  - Voxel status
- Task's completion status
  - Confidence state
  - Available information state



NBV planner based on updated status:



$$v = \arg\max_{v_x \in V} G(v_x)$$

Overlap constraint

$$W = \begin{cases} 1 & \text{if } \forall x, G_{fd}(v_x) == 0 \\ 0 & \text{otherwise} \end{cases}$$

Unknown voxels

$$G(v_x) = G_{ovlp}(v_x) \cdot \left(G_{fd}(v_x) + W \cdot G_{so}(v_x) \right)$$

$$G_{fd}(v_x) = \max_{i \in [1,I], J \in [1,J]} H(S_{cand} \mid es_i) \cdot \frac{n^{ij}(v_x)}{n_t^{ij}}$$

Conditional entropy

Visible feature ratio

中国科学院沈阳自动化研究所
SHENYANG INSTITUTE OF AUTOMATION CHINESE ACADEMY OF SCIENCES

WePo4: Poster Session IV (cont.)

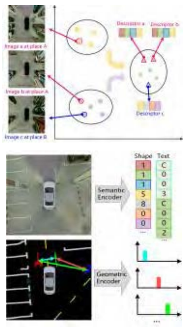
Room : Foyer, 1/F, 15:00-15:30, Wednesday, December 29, 2021

WePo4_2(7) 15:00–15:30

Visual Place Recognition via Semantic and Geometric Descriptor for Automated Valet Parking

Jingrui Yu and Jianbo Su
Department of Automation, Shanghai Jiao Tong University, China

- Parking lot environments with sparse and repetitive textures, viewpoint variations and dynamic disturbances pose challenges for place recognition that is critical to AVP.
- The proposed descriptor consists of two parts: a semantic vector and a geometric histogram. A coarse-to-fine framework for place recognition is proposed based on that.
- The vector encode both the number and type of shape and text semantics.
- The histogram represents the geometric pairwise relationships between landmarks.
- The descriptor has the potential to establish data associations between different sensing modalities.



WePo4_2(8) 15:00–15:30

Topological and Optimal Design of Grasping Manipulator for Obstacle Crossing Vehicle with Foldable Operating Arm

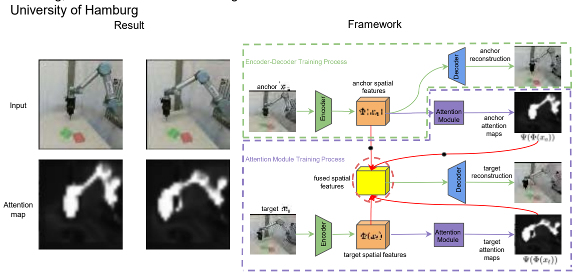
Yang Qi, Xiaochen Huang, Xiaojun Zhang, Zhanpeng Zhang, Hong Wang, Ruiyao Ou and Rui Zhang
Tianjin University of Technology and Education

- Aiming at the new demand for movable operating manipulators using on the spacecraft surface and lunar surface, an obstacle crossing vehicle with a foldable large workspace arm and a grasping manipulator is carried out. Firstly, the topological structures of the moveable vehicle is demonstrated in detailed by using the physical models of each part. Then, the forward position analysis of the manipulator is carried out, and the end pose of the manipulator is calculated. The correctness of the kinematic analysis of manipulator is verified by comparing theoretical result from MATLAB toll box with the simulation result obtained by SolidWorks. Finally, the kinematics performance evaluation index of the manipulator is defined, and is kinematic optimization is completed.

WePo4_2(9) 15:00–15:30

Self-supervised Attention Learning for Robot Control

Lin Cong, Yunlei Shi and Jianwei Zhang
University of Hamburg

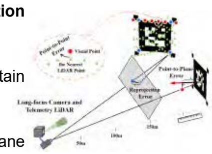


WePo4_2(10) 15:00–15:30

Long-focus Camera and Telemetry LiDAR Calibration for Rapid Transit Equipment

Bo Fu[1], Yanmei Jiao[1], Jian Bai[2], Jinhui Yuan[2]
Xin You[2], Qimeng Tan[3], Yue Wang[1] and Rong Xiong[1]
[1]Zhejiang University, China
[2]UniTTEC Co.,Ltd, China
[3]Beijing Institute of Spacecraft System Engineering, China

- A novel calibration solution which the **detection poses** as variables in optimization framework.
- Three **error terms** are constructed to obtain better estimation of the variables.
- Above error terms only require plane-to-plane **data association**, avoiding incorrect data association that leads to failure in calibration.



WePo4_2(11) 15:00–15:30

FRL-SLAM: A Fast, Robust and Lightweight SLAM System for Quadruped Robot Navigation

Chi Zhang, Zhong Yang, Qianhui Fang, Changliang Xu, and Hao Xu
College of Automation Engineering, Nanjing University of Aeronautics and Astronautics, China
Xiangrong Xu
Shool of Mechanical Engineering, Anhui University of Technology, China
Jianwei Zhang
Faculty of Mathematics, Informatics and Natural Science, University of Hamburg, Germany

- **Fast**: The bundle adjustment is restricted in a sliding window and the computation complexity is bound by marginalization scheme.
- **Robust**: The online rectifying of gravity vector enables roll and pitch to drift-free.
- **Lightweight**: The whole navigation system can run real time with CUDA accelerating on the embedded device carried by the quadruped robot.

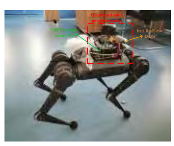


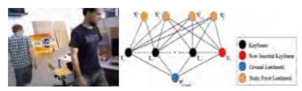
Fig. The MIT Mini Cheetah with the quadruped robot navigation suites

WePo4_2(12) 15:00–15:30

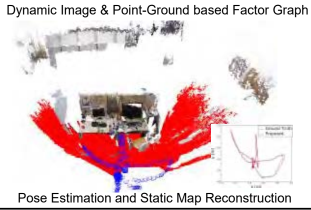
Ground Enhanced RGB-D SLAM for Dynamic Environments

Ruibin Guo[1] and Xinghua Liu[2]
[1]National University of Defense Technology, Hunan, China
[2]Academy of Military Science, Beijing, China

- Static point and ground features are detected and tracked to provide reliable constraints.
- A point-ground based factor graph is constructed to derive the cost functions for localization and mapping.
- Keyframe dynamic regions are repaired by a hybrid method combining the point projection method and homography-based projection method.



Dynamic Image & Point-Ground based Factor Graph



Pose Estimation and Static Map Reconstruction

WePo4: Poster Session IV (cont.)

Room : Foyer, 1/F, 15:00-15:30, Wednesday, December 29, 2021

WePo4_3(13) 15:00-15:30

Towards Real Time Interpretable Object Detection for UAV Platform by Saliency Maps

Maxwell Hogan and Nabil Aouf
Department of Electrical and Electronic Engineering, City, University of London, United Kingdom

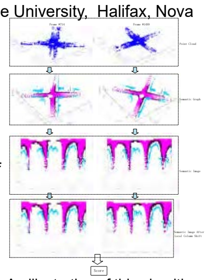
- Introduce an Image Tile Loader to improve small object detection from an aerial platform.
- Demonstrate the enhanced performance YOLOv5 and CenterNet-ResNet50 on small objects when using the Tile Loader.
- Present the use of Grad-CAM to improve explainability of a network of YOLO style architecture.

WePo4_3(14) 15:00-15:30

A Semantic-Based Loop Closure Detection of 3D Point Cloud

Yanfu Fan, Haihui Yuan, Shiqiang Zhu and Guangzhao Zhou
Intelligent Robot Research Center, Zhejiang Lab, Hangzhou, China
Jason Gu
Department of Electrical Engineering, Dalhousie University, Halifax, Nova Scotia, Canada

- It uses semantic information to complete the loop closure detection of point cloud data
- The semantic PCA algorithm determines the main axis direction, which realizes rotation invariance
- The local column shift reduces the influence of point cloud characteristics on the main axis
- Extensive experiments were conducted on the KITTI dataset to valid against other state-of-the-art methods



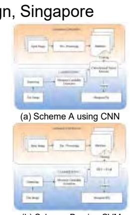
An illustration of this algorithm

WePo4_3(15) 15:00-15:30

A Classification Module for Automated Mosquito Surveillance Using Computer Vision

Masataka Fuchida and Ning Tan
Sun Yat-sen University, China
Hiroya Yatsuyanagi, Kazushige Okayasu and Akio Nakamura
Tokyo Denki University, Japan
Rajesh Elara Mohan
Singapore University of Technology and Design, Singapore

- An automated computer-vision-based mosquito-detection module is proposed.
- The design and implementation of two effective schemes for mosquito classification are reported.
- The performance comparison of classification of mosquitoes and fruit fly using both schemes is conducted.



(a) Scheme A using CNN

(b) Scheme B using SVM

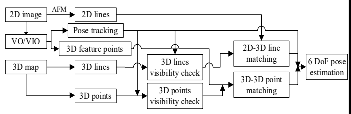
The system overview of two identification schemes

WePo4_3(16) 15:00-15:30

Visual Localization in a Prior 3D LiDAR Map Combining Points and Lines

Guangzhao Zhou, Haihui Yuan, Shiqiang Zhu, Zhiyong Huang, Yanfu Fan, Xinliang Zhong, Ruilong Du, Jianjun Gu
the Intelligent Robot Research Center, Zhejiang Lab, China

- Use learned-LSD algorithm to detect 2D lines
- Use Intensity-based algorithm to detect 3D lines
- Use triangulation to recover 3D sparse feature points
- Point and line features are composed of matching pairs to construct a cost function



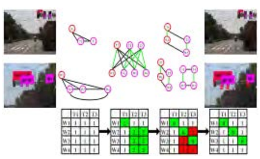
Pipeline of the proposed camera localization method

WePo4_3(17) 15:00-15:30

Topological Feature Based Object Matching for Traffic Light Detection Using Multi-view Camera System

Liyang Gao, Ming Yang, and Chunxiang Wang
Department of Automation, Shanghai Jiao Tong University, China
Yeqiang Qian
University of Michigan-Shanghai Jiao Tong University Joint Institute, Shanghai Jiao Tong University, China

- Multi-view camera system for traffic light detection.
- A new camera switching strategy with object matching and post-fusion algorithm.
- Topological feature based object matching algorithm.



the object matching algorithm of traffic light based on topological features

WePo4_3(18) 15:00-15:30

Real-Time Vision-Based Chinese Sign Language Recognition with Pose Estimation and Attention Network

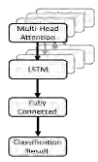
Sirui Cheng and Chaorui Huang
the School of Computer Science， Northeastern University, China
Zhaohui Wang
the Software College， Northeastern University, China

a. Introducing pose estimation in video sign language recognition , and improve the accuracy of the model.

b. Our model based on multi-head attention and LSTM solves the problem under time series situations.

c. Our methods have better results on mobile devices .

d. Our methods, using pose key points , can eliminate the effects of volunteer gender, clothing etc.



Overall Classification Model

WeC2: Rehabilitation & Assistive Robots

Session Chairs: Ningbo Yu and Yu Dang

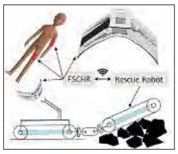
Room : Nan Shan A, 3/F, 15:30-16:45, Wednesday, December 29, 2021

WeC2(1) 15:30-15:45

First-aid Soft Constricting Hemostasis Robot Applied to Bleeding Limbs

Te Li, Kun Chen, Yuxin Li, Haibo Liu*, Kai Ma,Yongqing Wang
Key Laboratory for Precision & Non-traditional Machining of Ministry of Education, Dalian University of Technology, China

- In earthquake and other disaster sites, the robot provides unmanned automatic emergency stop bleeding.
- The soft hemostatic robot is inspired by humans to hold objects with fingers.
- A three-finger pneumatic arm realizes automatic and gentle winding of different diameters(82-104cm) limbs.
- The hemostatic pressure of the upper limbs robot prototype is above 40kPa.



First-aid soft constricting hemostasis robot(FSCHR)

WeC2(2) 15:45-16:00

Design of a Walking Assistive Robot Against Festination and Freezing of Gait

Yugen You, Yuke Wang, Jianda Han, Ningbo Yu*
College of Artificial Intelligence, Nankai University, China
Weijia Hou, Yang Yu, Jialing Wu*
Department of Rehabilitation Medicine, Tianjin Huanhu Hospital, China

- A walking assistive robot is designed to assist the subjects against festination and freezing of gait.
- Real-time cues are provided to help initialize the stepping motions.
- Feedback images are displayed on-line based on the ground reaction force data to reinforce the awareness of heel-to-toe gait.

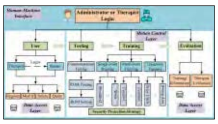
Walking assistive robot system

WeC2(3) 16:00-16:15

An Integrated Software System Designed for Upper Limb Rehabilitation Robot

Yuhui Cen, Jianjun Yuan, Sheng Bao and Liang Du
Shanghai Robotics Institute, Shanghai University, China
Shugen Ma
Department of Robotics, Ritsumeikan University, Japan
Weiwei Wan
Graduate School of Engineering Science, Osaka University, Toyonaka, Japan

- To improve the treatment efficiency problem, an integrated software system is proposed
- All information of therapists and patients is administrated digitally through a three-layer administration framework
- A multi-modal training method library is developed to assist therapists in formulating individualized rehabilitation training programs
- A safety protection strategy is proposed based on a joint angle filtering algorithm


Architecture of the proposed software system

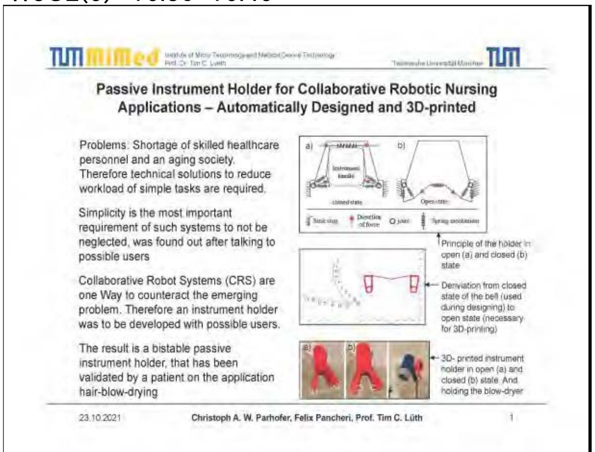
WeC2(4) 16:15-16:30

Haptic Bimanual System for Teleoperation of Time-Delayed Tasks

Aran Sena[1], Quentin Rouxel[2], Ekaterina Ivanova[1]
Etienne Burdet[1], and Zhibin Li[2]
1: Bioengineering, Imperial College London, UK
2: Informatics, University of Edinburgh, UK

- Future space missions aim to establish habitats on lunar and planetary surfaces, with robotic assembly systems performing the initial development of these facilities.
- We present a haptically controlled bimanual system, designed to investigate teleoperated assembly tasks, and better understand the associated challenges in time-delayed communications, mental load estimation, and variable autonomy.

WeC2(5) 16:30-16:45



WeC3: Robotic Exoskeletons

Session Chairs: Lianqing Liu and Wenyuan Chen

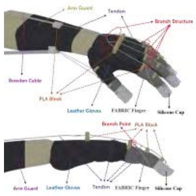
Room : Nan Shan B, 3/F, 15:30-16:45, Wednesday, December 29, 2021

WeC3(1) 15:30–15:45

A Biomimetic Tendon-driven Soft Hand Exoskeleton for Finger Extension based on Musculoskeletal and Biomechanical Principles

Wenyuan Chen, Ning Li, Wenxue Wang, Peng Yu, and Lianqing Liu
Shenyang Institute of Automation, Chinese Academy of Sciences, China
Guangyong Li
Department of Electrical and Computer Engineering, Swanson School of Engineering, University of Pittsburgh

- The human musculoskeletal model and sports biomechanical principles were analyzed for finger extension.
- A biomimetic tendon-driven soft hand exoskeleton was designed for finger extension.
- The stroke patient achieved a similar angular coupling relationship to the healthy subject.



WeC3(2) 15:45–16:00

Integration mode of standing balance and trajectory training based on lower limb rehabilitation exoskeleton

Tong Zhou, Jianjun Yuan, Sheng Bao and Liang Du
Shanghai Robotics Institute, Shanghai University, China
Shugen Ma
Department of Robotics, Ritsumeikan University, Japan
Tieshi Zhao, Zhongying Liu and Ye Zhang
Parallel Robot and Mechatronic System Laboratory, Yanshan University, China

- An innovative rehabilitation exoskeleton prototype was proposed for balance training and gait training.
- Kinematics-based control model was applied to center of gravity transfer and trajectory planning.
- An integration mode of standing balance and trajectory training was designed to enhance rehabilitation training.

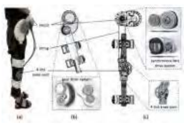
Human subject experiment

WeC3(3) 16:00–16:15

A Modular Lower Limb Exoskeleton System with RL Based Walking Assistance Control

Yutian Shen, Yingying Wang, Ziqi Zhao and Chenming Li
Electronic Engineering, The Chinese University of Hong Kong, HK, China
Max Q.-H. Meng
Electronic andElectrical Engineering, SUSTech and CUHK, Shenzhen, China

- A lower-limb exoskeleton system with compact design and modular actuation is presented to provide walking assistance.
- A reinforcement learning based control algorithmis proposed to provide assistance control where the exoskeleton-human system is modelled as a leader-follower system.
- Experiments are conducted on a built simulation platform with data partially collected from the exoskeleton-human system to validate the proposed controller.



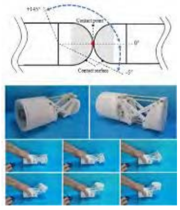
(a) Prototype of the exoskeleton system. (b) Hip joint module. (c) Knee joint moudle.

WeC3(4) 16:15–16:30

Design and Modeling of a Novel Cable-Driven Elbow Joint Module for Humanoid Arms

Zhihao Liang Yisheng Guan* Chaoqun Xiang and Yaowei Song
Guangdong University of Technology (GDUT)
Guangzhou, Guangdong, China.

- The modular design of the elbow improves the humanoid arm's versatility and extensibility.
- The elbow module size and forms of motion are consistent with humans.
- The cable-driven method is used to ensure lightweight and flexibility.
- Elbow module forward and inverse kinematics of the anti-parallel mechanism are analyzed.



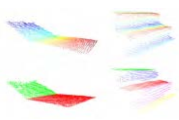
Cable-driven elbow module

WeC3(5) 16:30–16:45

Stair and Ramp Recognition for Powered Lower Limb Exoskeletons

Konstantin Struebig, Niklas Ganter, Leon Freiberg and Tim C. Lueth
Chair of Micro Technology and Medical Device Technology
Technical University of Munich, Germany

- Machine vision for powered lower limb exoskeletons promises higher efficiency overcoming obstacles
- The goal is to classify obstacles and measure their quantitative characteristics and distance
- The proposed system uses a depth sensing stereo camera and the RANSAC algorithm
- The system shows high accuracy, but suffers from long process run times



Segmentation of Ramps and Stairs using the RANSAC algorithm.

WeC4: System Design & Optimization II

Session Chairs: Yong Jiang and Kunlong Hong

Room : Liang He Room, 3/F, 15:30-16:45, Wednesday, December 29, 2021

WeC4(1) 15:30–15:45

The Robot of Human Anti-visual Vertigo Ability Evaluation Based on Virtual Reality Technology

Jinbao Li,Tengfei Li,Haichuan Ren*,Hang Li,Qiwei Shi,Xuan Liu,Xiong Chen

School of Electrical Engineering,Zhengzhou University, China

- Visual vertigo is often caused by visual stimuli in life.
- The robot of human anti-visual vertigo evaluation is developed based on the virtual reality technology.
- Machine learning technology is used to quantitatively classify human anti-visual vertigo ability.

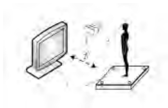


Fig.1. The structure diagram of robot
1-Upper computer
2-Dynamometer
3-Single-channel EEG sensor
4-VR glass

WeC4(2) 15:45–16:00

Design of a Rigid-Flexible Coupling Origami Gripper

Dongbo Liang†, Yinghao Gao†, Hailin Huang, Bing Li

The School of Mechanical Engineering and Automation, Harbin Institute of Technology, Shenzhen, China

- Rigid-flexible coupling gripper is developed by attaching stainless steel facets to the soft body of waterbomb mechanism, which increases its stiffness and therefore improved its load capacity.
- The rigid-flexible gripper is equipped with a sensory system composed of three self-made pressure sensors, which shows distinct responses to objects with different shapes.
- The sensory system shows ability to recognize grasping objects.

The rigid-flexible coupling gripper and its sensory system

WeC4(3) 16:00–16:15

Design and Analysis of Multi-DOF Adsorption Parallel Robot Based on Hybrid Mechanism

Kefeng Ye[1], Zhenya He[1,2,*], Guojian Huang[3], Xianmin Zhang[1], Haolun Yuan, Liang Wang

[1] School of Mechanical and Automotive Engineering, South China University of Technology, China
[2] The State Key Laboratory of Fluid Power and Mechatronic Systems, Zhejiang University, China
[3] School of Electrical Engineering, Guangdong Mechanical & Electrical, China

- The robot is composed of hybrid mechanism.
- The 3-RRR spherical parallel mechanism, and Delta parallel mechanism were designed respectively.
- The robot has 6 degrees of freedom, including 3 translational directions and 3 rotational directions.
- The adsorption mechanism based on the bionic design method was presented for in-situ machining.

Multi-DOF adsorption type parallel mechanism

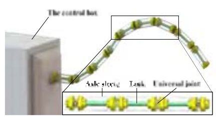
WeC4(4) 16:15–16:30

A Cable-Driven Hyper-Redundant Robot with Angular Sensing

Yuxuan Mao[1], Jiangbo Yu[1], Long Wang[2], Yun Zou[3], Zecai Lin[4], Weidong Chen[4], and Anzhu Gao[4]

1 Department of Mechanical Engineering, Shanghai Jiao Tong University, China
2 Science and Technology on Reliability and Environmental Engineering Laboratory, Beijing Institute of Structure and Environment Engineering, China
3 Department of Bioengineering, Shanghai Jiao Tong University, China
4 Department of Automation, Shanghai Jiao Tong University, China

- Use algorithm of two-layer optimization to achieve the follow-the-leader control
- Use multi-sensor fusion (angle, force and position) to form a closed-loop control
- Feasible for different target curves in 3D.
- Average positioning error for the tip is 5.27 mm, regarding a length of 220 mm (3 sections)



The schematic diagram of the developed cable-driven multi-section robot.

WeC4(5) 16:30–16:45

CameraRoach: various electronic backs packs for Search and Rescue

Sriranjan Rasakatla, Takeshi Suzuki, Wataru Tenma and Ikuo Mizuuchi

Tokyo University of Agriculture and Technology

***Abstract*—This paper describes a WiFi-enabled cyborg cockroach equipped with a wireless camera to send video telemetry feedback to the use/controller for search and rescue. We developed our own electronic hardware and software for the neural stimulation of the cockroach to make it navigate in a maze and send high-resolution wireless video feedback back to the user/controller for inspection or search and rescue. We describe our design of the cyborg cockroach, and present results of an evaluation experiment. We describe our unique electronic backpacks we developed for the cyborg insect which includes a GPS and a thermal camera.**

WeC5: Dynamics & Control II

Session Chairs: Houde Dai and Yanding Qin

Room : Nan Hai Room, 3/F, 15:30-16:45, Wednesday, December 29, 2021

WeC5(1) 15:30–15:45

Design and Control of a Magnetic Driven Worm-like Micro-robot

Chupeng Tang and Hailin Huang
School of Mechanical Engineering and Technology, Harbin Institute of Technology, China

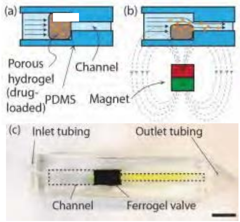
(1) Use a single soft sheet to realize the functions required by the robot;
(2) Driven by the external magnetic field to achieve untethered drive;
(3) Realize the real-time positioning of dual magnetic targets.

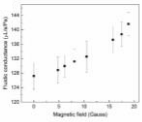
Magnetic driven dorm-like micro-robot

WeC5(2) 15:45–16:00

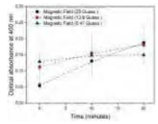
Magnetic hydrogel for simultaneous flow control and drug release

Hongjie Jiang, Yi Ma and Longya Xiao
South China University of Technology





Showing a fluidic conductance of 0.76 μL/Pa.s/Gauss



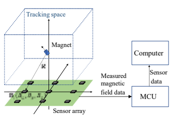
Showing a drug diffusion rate of 0.6%/min by 23 Gauss

WeC5(3) 16:00–16:15

Design and Experimental Testing of a Compact High-Precision Magnetic Tracking System

Bowen Lv, Yanding Qin, and Jiahao Xu
Department Name, University Name, Country College of Artificial Intelligence, Nankai University, China
Institute of Intelligence Technology and Robotic Systems, Shenzhen Research Institute of Nankai University, China
Houde Dai
Quanzhou Institute of Equipment Manufacturing, Haixi Institutes, Chinese Academy of Sciences, Jinjiang 362216, China.

- A high-precision magnetic localization system is established.
- The mean measurement error of 27 channels is 0.24 μT.
- During static tracking, the position and orientation error axially are less than 0.6 mm and 0.7°.
- The root mean square errors of position and orientation are 0.53 mm and 0.88°.



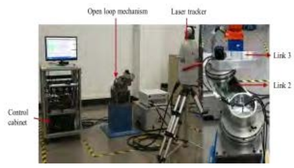
Schematic diagram of the magnetic localization scenario

WeC5(4) 16:15–16:30

Experimental Study on Dynamics of Open Loop Mechanism with Joint Clearance

Lixin Yang, Xianmin Zhang*
School of Mechanical & Automotive Engineering, South China University of Technology, China

- An experimental system was designed to study the influence of multiple clearance joints on the displacement, velocity and acceleration of the open loop mechanism.
- The results show that the joint clearance has little influence on the end displacement and velocity of the test platform, but has a great influence on the acceleration, and produces high frequency vibration.



Experimental system of the open loop mechanism with clearance joints

WeC5(5) 16:30–16:45

Sequential and Distributed Auction Based Robots Task Allocation for Objects Assembly

Abdelhafid Zenati and Nabil Aouf
Department of Electrical and Electronic Engineering, City, University of London, United Kingdom

- The aim of this work is to equip the RWAs with the skills of cooperatively unloading heterogeneous
- The global task allocation problem is translated to a mixed-integer nonlinear optimization (MINLO).
- We challenge the effectiveness of our approach on the above space exploration scenario.
- Our novel algorithm improves the distributed multi-robot task allocation results and achieves the desired aim of the work.

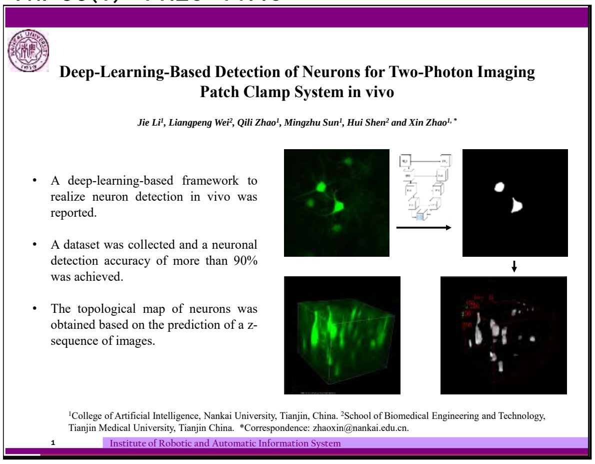
Technical Sessions

Thursday, December 30

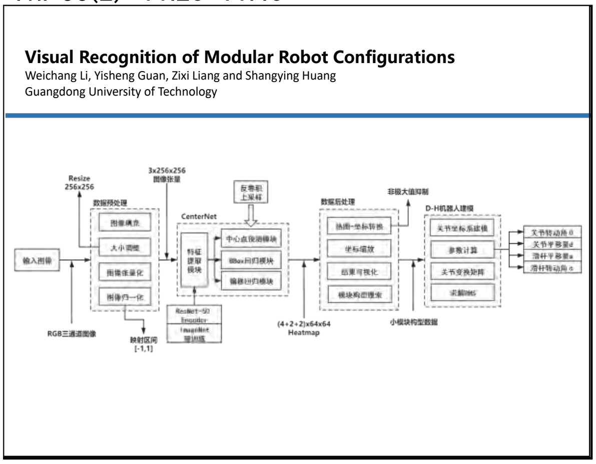
ThPo5: Poster Session V

Room : Foyer, 1/F, 11:20-11:40, Thursday, December 30, 2021

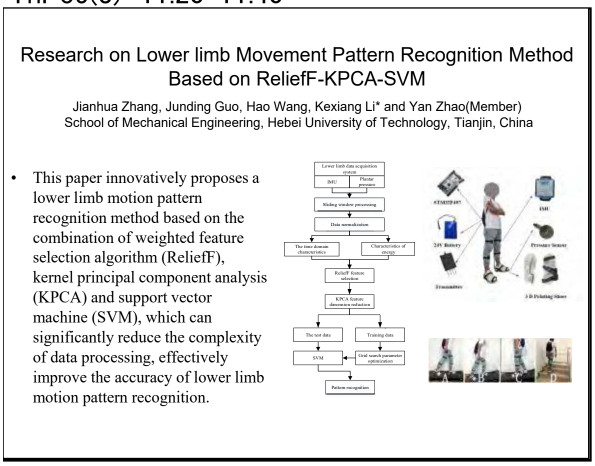
ThPo5(1) 11:20–11:40



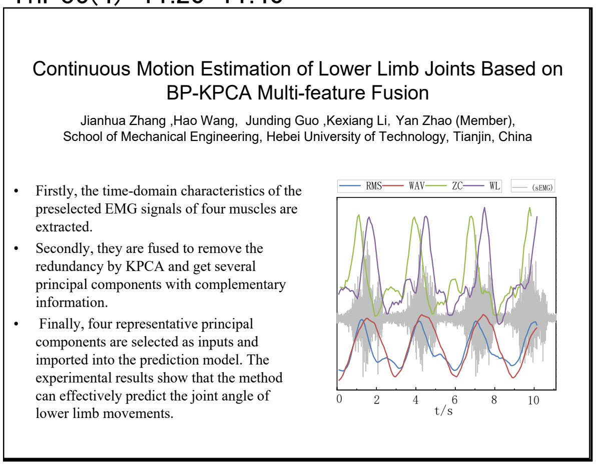
ThPo5(2) 11:20–11:40



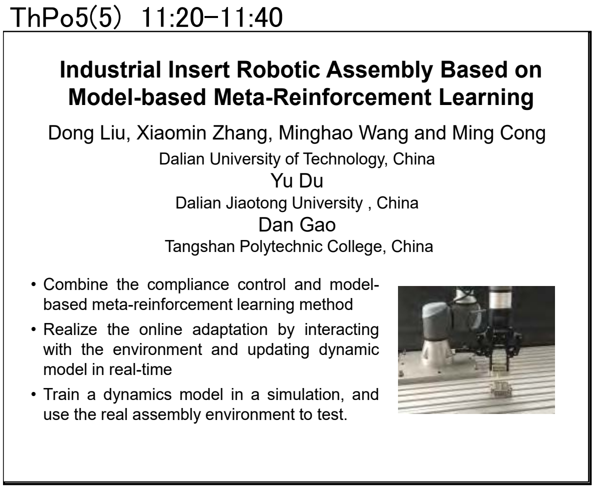
ThPo5(3) 11:20–11:40



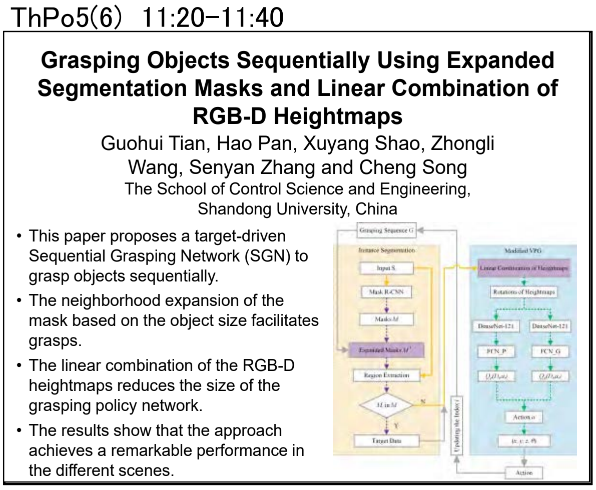
ThPo5(4) 11:20–11:40



ThPo5(5) 11:20–11:40



ThPo5(6) 11:20–11:40



ThPo5: Poster Session V (cont.)

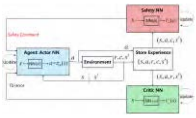
Room : Foyer, 1/F, 11:20-11:40, Thursday, December 30, 2021

ThPo5_2(7) 11:20−11:40

A Deep Safe Reinforcement Learning Approach for Mapless Navigation

Shaohua Lv, Yanjie Li*, Qi Liu, Jianqi Gao, Xizheng Pang and Meiling Chen
Department of Control Science and Engineering, Harbin Institute of Technology (Shenzhen), China

- Design the Actor-Critic-Safety architecture to apply CPO to navigation based on RL
- Increase the success rate and reduce the collision rate which proves the improvement of safety
- The planned path is almost comparable to ROS move_base which knows the global information
- The model can transfer to unseen dynamic environment with pedestrians which shows it generalizes well



Actor-Critic-Safety (ACS) architecture

ThPo5_2(8) 11:20−11:40

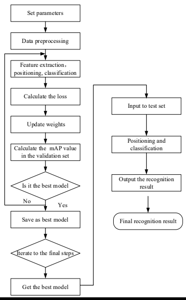
Towards the Urban Future: A Novel Trash Segregation Algorithm Based on Improved YOLOV4

Pan Zhou, Zuojun Zhu, Xiangrong Xu1* , Xuefei Liu, Bingwei He and Jianwei Zhang

This paper proposes a mobile trash segregation algorithm based on improved YOLOv4. In order to realize the efficiency of real-time outdoor trash detection by robot, we adopt a lightweight GhostNet as backbone of detection network. It mainly includes the following contributions:

1. Ghost Module is used in YOLOv4 to improve its network structure which has a good detection effect while reducing the parameters and calculation amount;
2. The data set is made, the parameters are adjusted and the trash detection network is trained, and the experiment results prove that the detection accuracy is higher and process of training and inference is faster;
3. The trash detection network is deployed on the mobile dual-arm cooperative robot to realize autonomous navigation, garbage identification and garbage pickup.

1. processing flow



2. Detection Results

3. Comparison

In order to measure the effectiveness of the lightweight module Ghostbottleneck used in this article, this paper analyzes the training and inference time of the original YOLOV4 algorithm and the improved YOLOV4 algorithm.

TABLE I. Comparing result of the speed between orignal yolov4 and improved yolov4

Model	Train(Hour)	Inference(Seond)
YOLOV4	1.24	0.15
IYOLOV4	1.12	0.12

TABLE II. Comparing result of the speed between orign yolov4 and improved yolov4

Model	AP(PB)	AP(GB)	AP(MC)	AP(CA)	mAP@0.5	mAP@.5:.95
YOLOV4	91.87%	92.76%	92.35%	93.18%	92.54%	89.76%
IYOLOV4	93.76%	94.92%	94.71%	95.93%	94.83%	91.25%

ThPo5_2(9) 11:20−11:40

An Improved Target Detection General Framework Based on Yolov4

Liu Hao, Xin Shan and Zhang Lei
Beijing University of Civil Engineering and Architecture

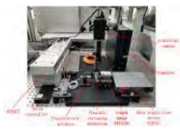
Abstract— The speed and precision of the target detection algorithm have received wide attention in the application. This paper proposes an improved network framework for the yolov4 algorithm, which improves the speed of detection and training. Firstly, the up-sampling and down-sampling links of the PANet are strengthened with an increased CBAM attention mechanism, which improve the algorithm ability to deal with the objects occlusion. The depth separable convolution is introduced to reduce the amount of model parameters and improves the algorithm speed. Secondly, the Se-Net attention mechanism is added to the residual module of CSPDarknet53 to pay more attention to the channel. Thirdly, Soft-NMS is used to optimize the screening of the detection frame during the detection process. Experiments show that the comparison of VOC2007 dataset is 84.26%, and in the VOC2007+VOC2012 dataset is 89.2%. The detection speed of FPS has increased by 2.21.

ThPo5_2(10) 11:20−11:40

Displacement measurement of micro-nano flexible mechanism based on

Yixi Zhang and Jiangang Li
School of Mechanical Engineering and Automation, Harbin Institute of Technology, China

- Micro-nano displacement measurement: Displacement measurement for micro-nano scale movement.
- Fusion algorithm: Multi-feature fusion is used to improve the anti-interference, stability and accuracy of the algorithm.
- Neural network: Neural network is used to replace camera calibration.



Displacement measurement experimental platform

ThPo5_2(11) 11:20−11:40

Deep Integrate Value Error for Trajectory Tracking Controller of Wheeled Inverted Pendulum Robot

Yujun Liu, Yutian Wang, Wenjie Li, Tao Cao, Zhidong Liu and Xian Guo*
College of Artificial Intelligence, NanKai University, China

- Trajectory tracking control of wheel inverted pendulum (WIP) robots
- A system of Forward Backward Stochastic Differential Equations
- Deep integrate value error (DIVE) algorithm

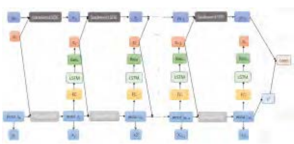


Fig. 1. LSTM network architecture

ThPo5_2(12) 11:20−11:40

A CNN-Based Position Control Method for Under-Actuated Cable-Driven Serpentine Manipulator

Jiahao Fang[1,2], Xueyi Zhang[1,2], Xingchao Wang[1,2], Xiaoqiang Ji[2], Ning Tan[3] and Zhenglong Sun[1,2]
[1]School of Science and Engineering, the Chinese University of Hong Kong, Shenzhen, Guangdong, China.
[2]Shenzhen Institute of Artificial Intelligence and Robotics for Society (AIRS), Guangdong, China.
[3]School of Computer Science and Engineering, Sun Yat-sen University, Guangzhou, China, and the State Key Laboratory of Robotics and Systems (HIT), Harbin, China.

- Suffering from assembly errors and deformation of components, the proper kinematics model of under-actuated cable-driven serpentine manipulator is unlikely to find.
- A CNN-based open loop control method was proposed to learn the actual kinematics of the serpentine manipulator.
- This method revises the control error with ideal kinematics modeled under ideal assumption.

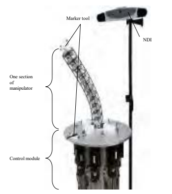


Fig.1. The manipulator and experiment setup

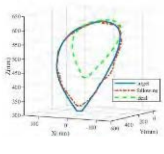


Fig.2. The result of the CNN-Based control

ThPo5: Poster Session V (cont.)

Room : Foyer, 1/F, 11:20-11:40, Thursday, December 30, 2021

ThPo5_3(13) 11:20−11:40

Machine Vision-based Identification and Positioning System for Domestic Garbage

Zhao Zhang*, Lei Zhang* and Shan Xin
Beijing University of Civil Engineering and Architecture

Domestic garbage classification is a global issue, and the robotic arm grasping system for garbage sorting can greatly improve sorting efficiency. Such robotic systems recognize and locate garbage by machine vision. The problems of existing garbage classification systems are as follows: the recognition rate of small-sized garbage is low; garbage positioning is inaccurate and time-consuming when the environment is dim or light-reflection. To this end, the paper collects 3116 images of domestic garbage, and divides them into 4 major categories and 12 minor categories; and then proposes an improved CenterNet target detection algorithm which is combined with the convolutional attention and feature fusing; normalized cross correlation matching algorithm has been reformed to enhance the positioning accuracy in the light-reflection environment. In addition, pre-cutting and pre-matching are executed to improve object positioning. The experiments prove that the system can automatically complete the recognition and positioning of domestic garbage while ensuring accuracy and speed.

ThPo5_3(14) 11:20−11:40

3D Printed Optimization: Bayesian Neural Network Trade-Off between Cost and Load-Bearing

Xiaozhu Lin, Xianglong Tan, Longchuan Wang, Andre Rosendo
School of Information Science and Technology ShanghaiTech University
Shanghai, China

- Our method is based on Bayesian Neural Network.
- A bridge is used as an example to validate the effectiveness.
- Our new method helps structural designers simplify the design process.
- Our results show that we can find the best design in 23 iterations.
- Experiment error between actual load-bearing capacity and the predicted value is below 4.585%.

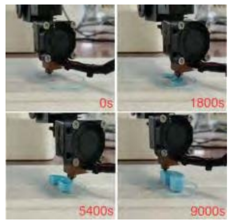


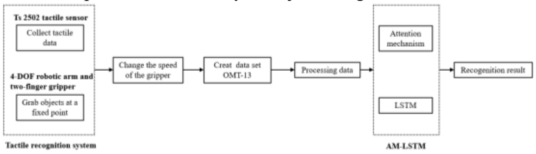
Fig.1: The process of 3D printing.

ThPo5_3(15) 11:20−11:40

Robotic Tactile Recognition system Based on AM-LSTM Model

Zhe Xu[1], Wei Yi[1], Muxin Chen[1] and Chunfang Liu[1]
Department of Information, Beijing University of Technology, Beijing, China

- Established a tactile recognition system to create a tactile dataset OMT-13.
- In the process of verifying the AM-LSTM model in the dataset, it was found that the different closing speeds of the gripper has a certain impact on the accuracy of object recognition.



Structure diagram of tactile recognition system

ThPo5_3(16) 11:20−11:40

A Deep Learning Network for Action Recognition Incorporating Temporal Attention Mechanism

Yue Liu, Xin Shan, Zhang Yu and Zhang Lei
Beijing University of Civil Engineering and Architecture

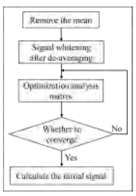
To address the problem that traditional action recognition methods do not perform well in complex video environments, in this paper a method for pedestrian action recognition in complex environments is proposed. A network for action recognition incorporating temporal attention mechanism is proposed. The main improvement of the method is as follows: Firstly, RCNN network is used for pedestrian detection to get the locations of all pedestrians in videos. Secondly, long and short term memory network (LSTM) is used to extract temporal features. On one hand, the network uses a residual part incorporating a spatial attention mechanism to extract the spatial features, which could reduce the interference from the image background. On the other hand, the Temporal Attention Mechanism (TAM) is proposed, which dynamically allocates video frame sequence weights according to the importance of LSTM output. Finally, experiments are conducted on the UCF101 dataset to verify the improvement of the accuracy and precision of the method.

ThPo5_3(17) 11:20−11:40

ICA and PIND based Remainder Particle Detection Technique for Space-borne Equipment

Zhishuai Jiang
Northeastern University at Qinhuangdao, China
Yuliang Zhao
Northeastern University at Qinhuangdao, China

- Particle impact noise detection (PIND) is usually used to detect remainder particle
- Independent component analysis (ICA) is an effective audio signal separation technique
- The system uses ICA technology to separate PIND sound and environmental noise
- Through many experiments, the accuracy of noise removal through ICA and PIND fusion method reaches 100%



ICA algorithm flow chart

ThPo5_3(18) 11:20−11:40

A non-rigid dynamic scene reconstruction method based on surface element model

Jiang Yong and Zeng Yujing
State Key Laboratory of Robotics Shenyang Institute of Automation, China
College of Information Science and Engineering, Northeastern University, China
Du Jingbo and Wang Fei
College of Automation and Electrical Engineering, Shenyang Ligong University, China
Robotics Academy, Northeastern University, China

- I.Foreword
- II.General architecture for non-rigid scene reconstruction
- III.3D Scene Reconstruction Algorithm
- IV.Experimental Analysis

3D reconstruction of model sequences from Boxing dataset

ThA1: Motion Planning I

Session Chairs: Jiankun Wang and Zhao Guo

Room : Phoenix Ballroom, 1/F, 11:40-12:55, Thursday, December 30, 2021

ThA1(1) 11:40-11:55

CNN-based path planning on a map

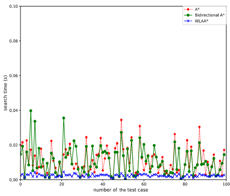
Daniele Sartori[1], Danping Zou[1], Ling Pei[1] and Wenxian Yu[1]
[1] Shanghai Jiao Tong University, Shanghai, China

ThA1(2) 11:55-12:10

WLAA*: A Time-efficient Method for Path Planning in Warehouse Environments

Maoqing Shi, Pengfei Duan, Tao Yu, and Shengwu Xiong
School of Computer and Artificial Intelligence,
Wuhan University of Technology, China.

- A time-efficient method for path planning in warehouse environments.
- An algorithm that can identify the layout of a warehouse.
- 3-aspect simulation experiments prove the efficiency of the proposed method.



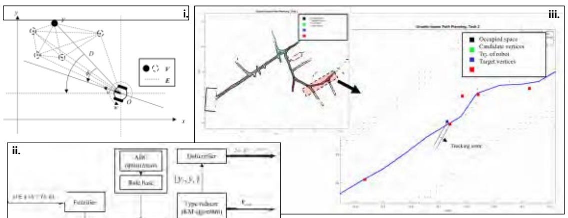
100 samples of all comparisons

ThA1(3) 12:10-12:25

Graph-based Path Planning and ABC-optimized IT2FLS for Autonomous Mobile Robot Exploration Within Unknown Environments

- Su-Feng Hu, Wu Chen, Meng-Ying Wu, Tian-Jiao Liao, and Hung-Chyun Chou

- An artificial bee colony (ABC)-based interval type-2 fuzzy logic system (IT2FLS) for the trajectory tracking of mobile robots



i. Graph-based path planning and trajectory tracking model
ii. Architecture of IT2FLS
iii. Path planning and tracking result

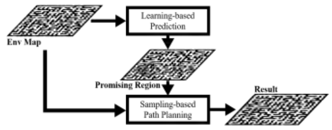
ThA1(4) 12:25-12:40

Learning-based Fast Path Planning in Complex Environments

Jianbang Liu, Baopu Li, Tingguang Li, Wenzheng Chi
Jiankun Wang* and Max Q.-H. Meng*

Our contributions are summarized as follows:

- A novel sampling method for fast path genera- tion in complex environments;
- An efficient neural network to predict the promising region for the given complex environ- ment;
- A series of case studies to demonstrate the advantage of the proposed algorithm.

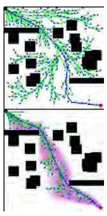


ThA1(5) 12:40-12:55

A Nonuniform Sampling Strategy for Path Planning Using Heuristic-based Certificate Set

Han Ma, Jianbang Liu, Fei Meng, Jin Pan
Electronic Engineering, The Chinese Univerisity of Hong Kong, Hong Kong
Jiankun Wang and Max Q.-H. Meng
Electric and Electronic Engineering, Sourthern Univerisity of Science and Technology, China

- The heuristic-based certificate set consists of sampled states with collision status and the minimum distance to the nearest obstacle, while the heuristic is given by the neural network.
- The simulation results demonstrate that the nonuniform sampling strategy significantly speeds up these algorithms and improves their stability.

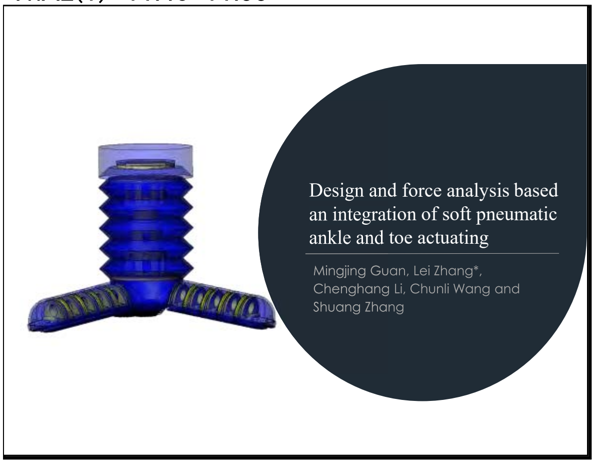


ThA2: Sensing & Estimation II

Session Chairs: Fei Wang and Hao Liu

Room : Nan Shan A, 3/F, 11:40-12:55, Thursday, December 30, 2021

ThA2(1) 11:40–11:55

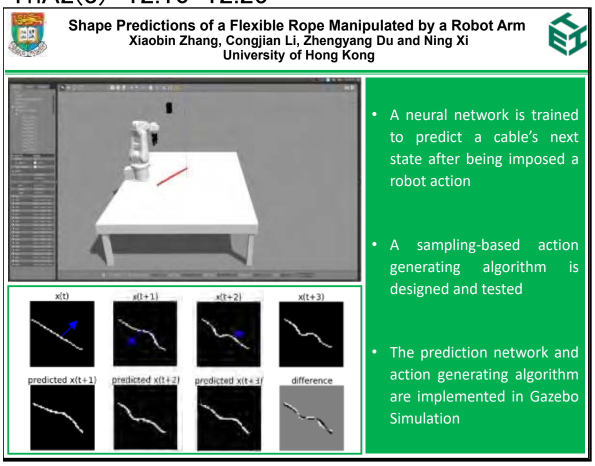


ThA2(2) 11:55–12:10

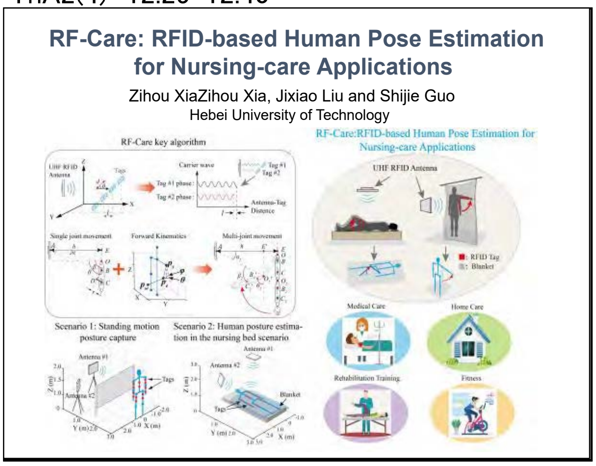
Magnetometer-Free IMU-Based Joint Axis Calibration and Estimation

Linhang Ju[1], Lufan Mo[1], Yanjun Shi[1], Di Shi[1] and Wuxiang Zhang[1]
[1] Beihang University

ThA2(3) 12:10–12:25



ThA2(4) 12:25–12:40



ThA3: Detection & Learning

Session Chairs: Guangyi Shi and Liang Zhao

Room : Nan Shan B, 3/F, 11:40-12:55, Thursday, December 30, 2021

ThA3(1) 11:40–11:55

Continuous sEMG estimation method of upper limb shoulder elbow torque based on CNN-LSTM

Cunxin Li, Xiaodong Zhang, Hanzhe Li and Haibo Xu
School of Mechanical Engineering,
Xi'an Jiaotong University
Shaanxi, China

- Committed to providing technical support for exoskeleton assist efficiency evaluation.
- According to the lifting process, a simplified two link model of the upper limb is established and the dynamic analysis is carried out.
- CNN-LSTM neural network is established to estimate the torque of upper limb shoulder and elbow joint.

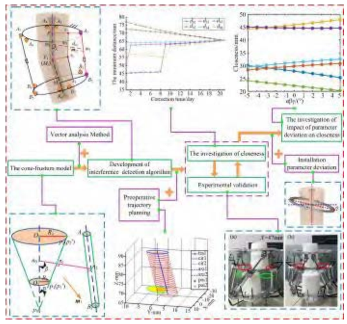
Heavy lifting

ThA3(2) 11:55–12:10

IEEE ROBIO 2021 Sanya, China, 27-31 DEC 2021

Title: Establishment and validation of the interference detection algorithm applied in limb deformity correction

Author: Guotong Li, Jianfeng Li, Mingjie Dong, Shiping Zuo, Ran Jiao, Shuang Wang
College of Mechanical Engineering and Applied Electronics Technology,
Beijing University of Technology, Beijing, 100124, China
E-mail: dongmj@bjut.edu.cn



ThA3(3) 12:10–12:25

Active Semi-supervised Grasp Pose Detection with Geometric Consistency

Fan Bai and Delong Zhu and Hu Cheng and Peng Xu
Electronic Engineering, The Chinese University of Hong Kong, China
Max Q.-H. Meng
Electronic and Electrical Engineering, Southern University of Science and Technology, China

- This is the first work that leverages active learning and semi-supervised learning to solve the problem of grasp pose data.
- We propose the GCCoreSet strategy combining geometric consistency for core-set selection.
- We achieve semi-supervised training with labeled data and unlabeled data using geometric consistency constraints.
- The proposed method is tested on a general dataset and compared with other methods, achieving superior performance.

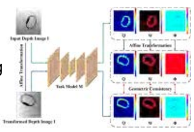


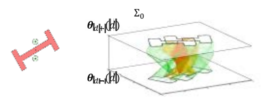
Illustration of grasp geometric consistency. The affine transformations include translation, rotation, and zoom.

ThA3(4) 12:25–12:40

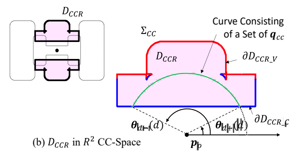
An Algorithm on Checking 2-Finger Object Caging in Plane by Using Dual CC-Closure Region Concept

Koki Shirota, and Zhidong Wang
Department of Advanced Robotics
Chiba Institute of Technology, Japan

- In-plane two-finger caging problem is discussed in C-Object Closure Space.
- A Dual CC-Closure Region(*DCCR*) that can be used for checking of two-finger object caging with less calculation cost is proposed.
- Caging verification is reduced from SE(2) shape verification to a *DCCR* calculation in R^2 space plus a checking procedure of a circular arc path in R2 space.



(a) *C-Closure Object Region and* C_{free_obj} in $SE(2)$ *C-Space*



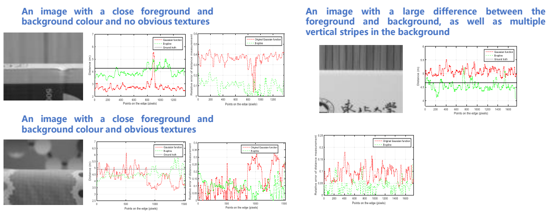
(b) D_{CCR} in R^2 CC-Space

ThA3(5) 12:40–12:55

Distance Measurement Method Based on Re-blurring with B-spline Function

Yangjie Wei*, Rui Liang, Weihan Hou
College of Computer Science and Engineering, Northeastern University

- In this paper, a distance measurement method based on re-blurring with the cubic B-spline wavelet function is proposed.
- The relationship between the Gaussian function and the B-spline function is analyzed theoretically.
- Owing to the advantages of B-spline in the progressive optimization, the cubic B-spline wavelet function is introduced to replace the traditional Gaussian function in the re-blur process, resulting into a higher precision of distance measurement.



ThA4: Robot Vision I

Session Chairs: Caiming Sun and Yaowei Liu

Room : Liang He Room, 3/F, 11:40-12:55, Thursday, December 30, 2021

ThA4(1) 11:40−11:55

View Loss Evaluation and Keyframe Reselection for Active Aerial Visual Reconstruction

Yaojing Li and Hongpeng Wang and Xiaoyang Zhang and Jingtai Liu and Xinwei Chen
Nankai University, China,
Shenzhen Research Institute of Nankai University, China
Minjiang University, China

- Conduct quartered depth histogram feature to serve as observation for pose and position estimation.
- Define and classify the view loss to give a quantitative evaluation for keyframe reselection.
- Improve the quality of the 3D reconstruction by keyframe reselection method.

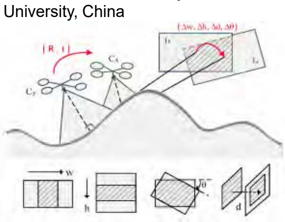


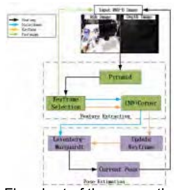
Figure. View loss in different directions caused by the pose and position transformation of actual camera frame.

ThA4(2) 11:55−12:10

Robust Edge-Direct Visual Odometry based on CNN edge detection and Shi-Tomasi corner optimization

Kengdong Lu[1], Jintao Cheng[1], Yubin Zhou[1], Juncan Deng[1], Rui Fan[2], Kaiqing Luo[1]
1.School of Physics and Telecommunication Engineering, South China Normal University, Guangzhou 510006, P. R. China.
2. R. Fan is with the College of Electronic and Information Engineering, Tongji University, Shanghai 201804, P . R. China

- Combining CNN edge detection and Direct-VO into Edge-direct VO achieves excellent performance.
- Proposing an improved Shi-Tomasi corner optimization for edge maps.
- Combining the dual mechanism of periodicity and motion amplitude to update key frames.



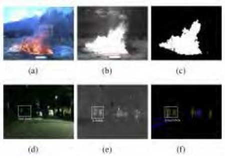
Flowchart of the our method

ThA4(3) 12:10−12:25

Real-Time Flame Segmentation based on RGB-Thermal Fusion

Shuaihao Guo, Biao Hu, Ran Huang
College of Information Science and Technology,
Beijing University of Chemical Technology, China

- Designed a novel network model with an effective module, which can fuse RGB and thermal images for segmentation.
- The network model achieves superior performance than several state-of-the-art models on different datasets.
- RGB and thermal information is applied to the field of flame segmentation by deep learning.



Some images in datasets.

ThA4(4) 12:25−12:40

Visual-Semantic Graph Attention Networks for Human-Object Interaction Detection

Zhijun Liang[1] and Junfa Liu[1] and Yisheng Guan[1] and Juan Rojas[2]
[1]School of Electromechanical Engineering, Guangdong University of Technology, China.
[2]Department of Mechanical and Automation Engineering, Chinese University of Hong Kong, China.

- Learning interactions between humans and objects is important for robot to further understand the visual world.
- Most previous works just leveraged local object-pair features while ignored informative cues from surrounding objects.
- A dual-graph attention network is proposed to consider contextual cues and intrinsic semantic regularities for HOI detection.
- Competitive results are obtained on two common benchmarks.

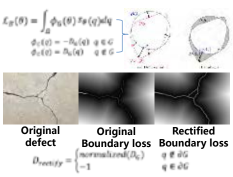
What's the action between the boy and the cake? *Cut* or *light*? Check the answer in the paper.

ThA4(5) 12:40−12:55

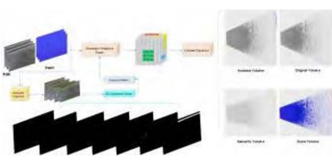
Small Defect Instance Reconstruction Based on 2D Connectivity-3D Probabilistic Voting

Kunlong Hong, Hongguang Wang, and Bing Zhu
State Key Laboratory of Robotics, Shenyang Institute of Automation, Chinese Academy of Sciences, Shenyang
Three Gorges Power Plant, China Yangtze Power Co., Ltd.

Rectified Boundary Loss for small defect segmentation



2D connectivity - 3D Probabilistic Voting for Consistent Reconstruction of Sparse Defects



2021/12/19 1

ThA5: Planning & Control II

Session Chairs: Xiao Liang and Ningbo Yu

Room : Nan Hai Room, 3/F, 11:40-12:55, Thursday, December 30, 2021

ThA5(1) 11:40–11:55

Single-Dimensional Intuitive teaching Control for Constrained Space Robotic Manipulation

Hang Gao[1], Zhang Xiaodong[2], Huanbin Xu[2], Tao Xiao[2] and Chao Ma[1]

[1] University of Science and Technology Beijing

[2] Beijing Institute of Spacecraft System Engineering

ThA5(2) 11:55–12:10

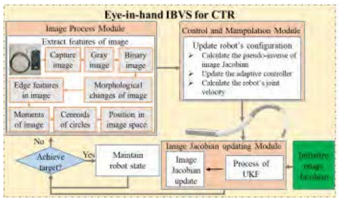
Visual Servoing Control of Concentric-tube Robot with Jacobian Matrix Estimation

Xing Yang[1], Guangdu Cen[1], Chao Zhang[1], Jiaole Wang[1], Shuang Song[1], Max Q.-H. Meng[2]

1 School of Mechanical Engineering and Automation, Harbin Institute of Technology (Shenzhen)

2 Department of Electronic and Electrical Engineering, Southern University of Science and Technology

This paper proposes a model-free and uncalibrated approach to conduct eye-in-hand visual servoing for concentric-tube robots (CTRs) in minimally-invasive surgery. An adaptive controller is designed for fast convergence. We propose to numerically calculate an image Jacobian to map the image deviations to robot joint variables. The image Jacobian is online estimated based on unscented Kalman filter (UKF) without the prior knowledge of CTR kinematic model or hand-eye calibration. A customized observation function is constructed to describe the mapping relationship between state and measurement vectors.



The overall control strategy for CTR based on model-free and uncalibrated EiH IBVS

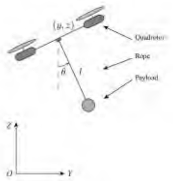
ThA5(3) 12:10–12:25

Continuous Finite-time Trajectory Tracking Control for Unmanned Quadrotor Transportation Systems

Yang Liu, Shizhen Wu, Zhaopeng Zhang, Xiao Liang, Jianda Han, Yongchun Fang

Institute of Robotics and Automatic Information System, Tianjin Key Laboratory of Intelligent Robotics, Nankai University, Tianjin 300350, China

- Compact dynamic model of the system with external disturbances is established.
- A continuous tracking control method based on terminal sliding mode (TSM) is developed.
- Stability analyses are illustrated.
- Simulation results are presented compared with the PD controller and LQR control scheme.



The Unmanned Quadrotor Transportation System.

ThA5(4) 12:25–12:40

Nonlinear Control for Dual-Rope Aerial Transportation System by Tilt-Rotor

Yang Wang, Hai Yu, Xiao Liang, Jianda Han, Yongchun Fang

Institute of Robotics and Automatic Information System, Tianjin Key Laboratory of Intelligent Robotics, Nankai University, Tianjin 300350, China

- This paper aims at dual-rope transportation system to guarantee safety and efficiency.
- A nonlinear controller is proposed without any linearization or approximation operations.
- The developed control system achieves asymptotic stability as guaranteed by LaSalle's invariance principle.
- Simulation results are presented to further reveal the system characteristics.

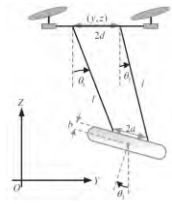


Illustration of dual-rope aerial transportation system

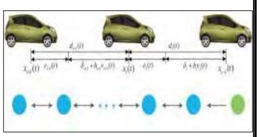
ThA5(5) 12:40–12:55

Dynamic Integral Sliding Mode for Vehicle Platoon Control with Constant Time Headway Policy

Yanbo Wang and Chenglin Liu

Key Laboratory of Advanced Process Control for Light Industry (Ministry of Education), Institute of Automation, Jiangnan University, China

- A coupled dynamic integral sliding mode control (DISMC) strategy is proposed for a vehicle platoon.
- The DISMC can reduced the chattering phenomenon of the controller caused by sign function.
- Coupled sliding mode surface with constant time headway policy is constructed for string stability.
- The vehicles system can be stable in fast finite time.



Configuration of vehicle platoon system

ThB1: Motion Planning II

Session Chairs: Jiankun Wang and Shan Guo

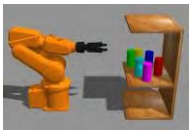
Room : Phoenix Ballroom, 1/F, 14:00-15:30, Thursday, December 30, 2021

ThB1(1) 14:00–14:15

Efficient Planning for Object Search Task Based on Hierarchical POMDP

Wenrui Zhao and Weidong Chen
Institute of Medical Robotics and Department of Automation, Shanghai Jiao Tong University, and Key Laboratory of System Control and Information Processing, Ministry of Education, China

- Object search in clutter suffers from perception uncertainty and large action space
- Hierarchical POMDP is used to plan under uncertainty and reduce computation complexity
- Probabilities of action feasibility are learned in execution and are used to determine action feasibility in belief tree search
- Extra reward and advance identification are utilized to further reduce motion planning time



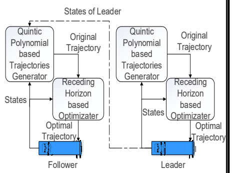
Object search task

ThB1(2) 14:15–14:30

Hierarchical platoon motion planning strategy based on leader-follower structure

Lingli Yu, Zhengjiu Wang, and Zongxu Kuang
Department of Automation, Central South University, No.932 South Lushan Road, Changsha 410083, Hunan, China

- A hierarchical platoon motion planning strategy based on leader-follower structure is developed
- A quintic polynomial based method is proposed to generate initial trajectories
- Receding horizon optimization is presented to optimize the initial trajectories

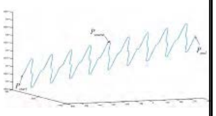


ThB1(3) 14:30–14:45

A Trajectory Planning Method for Industrial Robot Weaving Welding Based on Piecewise Function

Chenhang Jiao, Hongwei Li
KUKA robot Guangdong Co., Ltd, China

- Employed the cycloidal trajectory in piecewise function
- Conducted the contrast experiments in MATLAB
- Conducted the welding experiment in real robot



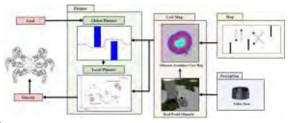
Weaving Trajectory

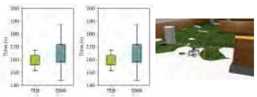
ThB1(4) 14:45–15:00

Motion Planning for Hexapod Robots in Dynamic Rough Terrain Environments

Bingyi Xia, Kaiwei Che, Zhilong Tang, Jiankun Wang, *Member, IEEE*, and Max Q.-H. Meng, *Fellow, IEEE*
Department of Electronic and Electrical Engineering, Southern University of Science and Technology
Bingyi Xia and Kaiwei Che contributed equally to this work

We propose a novel integrated motion planner or hexapod robots in dynamic rough terrain environment. The global planner employs the Bidirectional-RRT* algorithm and the TEB algorithm is used in the local planner.





The simulation experiments results demonstrate that our proposed method can achieve better performance on the motion planning process for the hexapod robot.

ThB1(5) 15:00–15:15

Automatic Scan Planning and Construction Progress Monitoring in Unknown Building Scene

Hao Shen[1], Xiang Li[1], Xin Jiang[1*] and yunhui Liu[2]
[1]Harbin Institute of Technology (Shen Zhen), China
[2]The Chinese University of Hong Kong, China

- The proposed method solves the scan planing problem in unknown building scene, which combines the RRT and NBV algorithms utilizing the prior information involved in construction drawing.
- The completeness of wall construction will be estimated after the full coverage scan.
- The proposed method is verified by experiments in simulation, laboratory building and construction site.

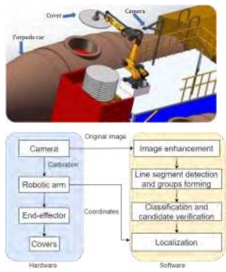
Automatic scan planning and construction progress monitoring system

ThB1(6) 15:15–15:30

Vision Based Polygon Detection System for Industrial Robots under Complex Illumination

Hao Gao[1], Weidong Chen[1], Ruimin Wu[2]
[1]Department of Automation, Shanghai Jiao Tong University, China
[2]Baoshan Iron & Steel Co. Ltd., China

- A polygon detection system for industrial robots under complex illumination.
- A image enhancement method based on histogram specification.
- A detection algorithm based on local features using a line segment detector.



Task flow and system architecture

ThB2: UAVs II

Session Chairs: Yu Dai and Yaowei Liu

Room : Nan Shan A, 3/F, 14:00-15:30, Thursday, December 30, 2021

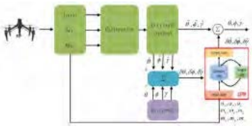
ThB2(1) 14:00–14:15

A Novel Hybrid Attitude Fusion Method Based on LSTM Neural Network for Unmanned Aerial Vehicle

Yaohua Liu[1,2,3], Yimin Zhou[3,*] and Yang Zhang[3]

[1]School of Nano-Tech and Nano-Bionics, University of Science and Technology of China, Anhui Province, China
[2]Suzhou Institute of Nano-Tech and Nano-Bionics, Chinese Academy of Sciences, Jiangsu Province, China
[3]Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, Shenzhen, China

- **In order to improve the UAV attitude fusion precision, a novel hybrid attitude fusion method is introduced in this paper.**
- **An error model between the IMU output and attitude is established by a long short term memory neural network (LSTM NN).**
- **The attitude fusion error can be estimated well by using the powerful nonlinear fitting and time series processing ability of the LSTM.**



The UAV attitude fusion scheme based on LSTM NN

ThB2(2) 14:15–14:30

The Development of a UAV Target Tracking System Based on YOLOv3-Tiny Object Detection Algorithm

Gan Liu, Ying Tan, Wenchuan Kuang, Binghua Li and Feng Duan
The Department of Intelligence Science and Technology, Nankai University, P. R. China
Lingfeng Chen
School of Mathematic and Statistics, Xi' an Jiaotong University, P. R. China
Chi Zhu
The Department of System Life Engineering, Maebashi Institute of Technology, Japan

- ***YOLOv3-Tiny*** target detection algorithm has a ***good effect in UAV target tracking system***
- The trained network can detect the target in the image at a ***very fast speed***
- Target tracking system controls the ***forward and backward movement*** and ***yaw angle change*** of UAV

Structure of UAV target tracking system

ThB2(3) 14:30–14:45

Fully Automated Control System for Recovery of Fixed-wing UAV*

Hongyu Nie, Mingxi Zhang, Feng Gu, Lingling Chu, Guangyu Zhang, Xintian Du, and Yuqing He

Shenyang Institute of Automation, Chinese Academy of Sciences

1. An automated shipborne release and recovery system for fixed-wing UAV to achieve recycling deployment of fixed-wing UAV applied in the deep sea.

2. An active flexible arresting hook is designed to compensating the rolling and pitch of the surface vehicle and dynamically match the altitude of the UAV.

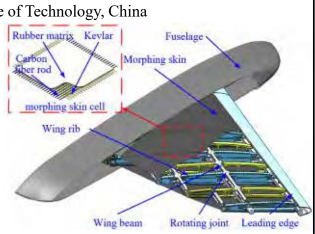
3 . Many ground and sea experiments and tests are conducted in different conditions to verify the feasibility and validity of the system.

ThB2(4) 14:45–15:00

Design and Analysis of a Variable-sweep Morphing Wing for UAV Based on a Parallelogram Mechanism

Guang Yang, Hongwei Guo, Hong Xiao, Yue Bai and Rongqiang Liu
State Key Laboratory of Robotics and System
Harbin Institute of Technology, China

- This paper proposed a new shear variable-sweep morphing wing based on a parallelogram mechanism.
- The kinematics model of the morphing wing is established, and the wing area, aspect ratio, root-to-tip ratio and relative thickness are analyzed and verified.
- Establish the skin buckling model, obtain the skin parameters that can be smoothly and continuously deformed within the range of sweep-angle changes and verify the skin smoothness.



The variable-sweep morphing wing model

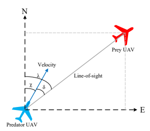
ThB2(5) 15:00–15:15

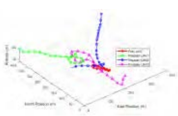
School of Automation Science and Electrical Engineering, Beihang University

Multi-UAV Interception Inspired by Harris' Hawks Cooperative Hunting Behavior

Bingda Tong, Jichuan Liu, Chen Wei and Haibin Duan*, *Senior Member, IEEE*

This paper presents an approach to intercept adversarial unmanned aerial vehicle (UAV) by using Harris' hawks (Parabuteo unicinctus) cooperative hunting behavior. A mixed guidance law suited to the Harris' hawks natural hunting style at high-speed is adopted for the leader UAV to intercept target UAV with good maneuverability and horizontal turning escape tactic. The "flush-and-ambush" strategy and "relay attack" strategy of Harris' hawks used in cooperative hunting are introduced for multiple UAVs interception in order to increase the probability of success.





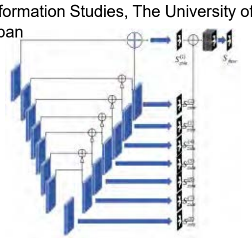
ROBIO 2021, Sanya, P.R. China

ThB2(6) 15:15–15:30

UA-net based Salient Object Detection Method for UAV

Lingfeng Chen
School of Mathematics and Statistics, Xi'an Jiaotong University, P. R. China
Gan Liu, Ying Tan and Feng Duan
The Department of Intelligence Science and Technology, Nankai University, P. R. China
Hangli Ge
The Graduate School of Interdisciplinary Information Studies, The University of Tokyo, Japan

- A network structure for **Salient Object Detection on UAV called UA-net** is presented refer to the structure of U-net.
- The trained network can **produce nice saliency map of pedestrians**.
- We used **bicubic interpolation** method and find it better than **bilinear and nearest interpolation method** in the network's **upsampling process**.



The UA-net structure diagram

ThB3: Dynamics & Control III

Session Chairs: Houde Dai and Yu Dang

Room : Nan Shan B, 3/F, 14:00-15:30, Thursday, December 30, 2021

ThB3(1) 14:00–14:15

Swinging Up and Balancing a Pendulum on a Vertically Moving Cart Using Reinforcement Learning

Poorna Hima Vamsi A, Mangesh D Ratolikar, and R Prasanth Kumar

- Balancing a pendulum on a horizontally moving cart is a classic benchmark problem for designing and testing control and reinforcement learning algorithms,
- Whereas vertically moving cart is rarely discussed due to relatively higher difficulty level in balancing it and no model environment is available.
- This paper presents:
  - A custom **OpenAI Gym** based environment for pendulum on a vertically moving cart with both discrete and continuous control settings.
  - Trained deep reinforcement learning agents which swings up and balance the pendulum in vertical position indefinitely without exceeding the displacement limits of the cart.
- Reward: $\mathbf{r = 0.1(\theta - \pi)^2 - 0.005|\theta - \pi|\omega^2 - 0.05|y|}$ (θ,ω:pendulum angle, ang.velocity, y:cart disp.)
- For discrete control, **Deep Q Network (DQN)** algorithm is used for training and for continuous case, **Soft Actor Critic(SAC)** is used.
- In both cases, the trained agents can swing up and quickly bring the pendulum to upright position and are able to balance the pendulum indefinitely within $\mathbf{1^0\text{-}2^0}$ from the upright position.
- The trained agents learned oscillatory force inputs which is similar to the theoretical solutions reported in the literature.

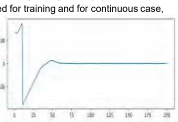


Fig.2 Pendulum angle vs time

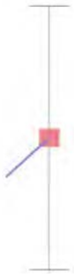


Fig.1 Environment

ThB3(2) 14:15–14:30

A Dynamic Adaptive Impedance Controller for Force Tracking of Dual-arm Manipulators in Uncertain Contact Environment

Xiaogang Song[1], Huan Mao[1], Hailin Huang[1], Wenfu Xu[1], and Bing Li[1,2]

1. School of Mechanical Engineering and Automation, Harbin Institute of Technology, Shenzhen, 518055, China
2. Peng Cheng Laboratory, Shenzhen, 518055, China

- A dual-loop dynamic adaptive impedance controller is presented for force tracking of dual-arm manipulators.
- A dynamic adaptive impedance control is proposed to eliminate system oscillation and avoid force overshoot.
- Test results show that the proposed approach can achieve good force tracking performance in uncertain environment.

The experiment platform

ThB3(3) 14:30–14:45

Sensitive Collision Detection of Second-Order Generalized Momentum Flexible Cooperative Joints Based on Dynamic Feedforward Control

Jie Wang, Yisheng Guan, Haifei Zhu,and Ning Xi

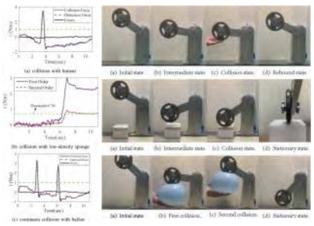
Biomimetic and Intelligent Robotics Lab (BIRL)

Guangdong University of Technology, Guangzhou 510006, China

Department of Industrial and Manufacturing Systems Engineering

The University of Hong Kong, HK SAR, China

- Flexible joints for collaborative robots.
- External force detection based on second-order momentum observer.
- Sensitive collision detection and identification.



Experiments with a collaborative joint

ThB3(4) 14:45–15:00

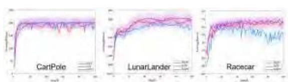
Shiftable Dynamic Policy Programming for Efficient and Robust Reinforcement Learning Control

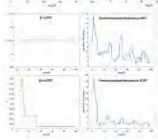
Zhiwei Shang[1,2], Huiyun Li[2] and Yunduan Cui[2]

[1]University of Chinese Academy of Sciences, China.

[2]Guangdong-Hong Kong-Macao Joint Laboratory of Human-Machine Intelligence-Synergy Systems, Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, Shenzhen, China.

- Extend the static penalty term of KL divergence in Dynamic Policy Programming(DPP)[1] to a dynamic one which is controlled by a shiftable parameter.
- Design a general parameter switch strategy for various tasks to dynamically switch the smoothness of policy update according to the historical learning performances.
- Propose a novel DRL algorithm SDPP by combining the two factors above and evaluate it by three benchmark tasks.





- The adaptively changing parameter of KL-divergence in the proposed SDPP contributes to less standard deviation of reward during training and therefore achieve smooth and efficient learning process in various benchmark problems.

[1] Azar, Mohammad Gheshlaghi, Vicenç Gómez, and Hilbert J. Kappen. "Dynamic policy programming." *The Journal of Machine Learning Research* 13.1 (2012): 3207-3245.

ThB3(5) 15:00–15:15

Adaptive NN based Visual Servoing Control for Robot Manipulator with Field of View Constraint and Dynamic Uncertainties

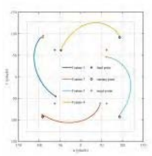
Jiao Jiang and Yaonan Wang

Electrical and Information Engineering, Hunan University, China

Yiming Jiang and Zhiqiang Miao

Electrical and Information Engineering, Hunan University, China

- Introduced a barrier Lyapunov function to design the controller of the visual servoing system.
- All signals of the closed-loop system are all restricted, while content the FOV constraints.
- The states of the closed-loop system finally converge to a compact set.
- Adaptive neural network control is applied to eliminate the uncertainties of the visual servoing system.



Evolution of the visual features in the image plane

ThB4: Robot Vision II

Session Chairs: Yu Dai and Liang Zhao

Room : Liang He Room, 3/F, 14:00-15:30, Thursday, December 30, 2021

ThB4(1) 14:00-14:15

中国科学院深圳先进技术研究院
SHENZHEN INSTITUTES OF ADVANCED TECHNOLOGY CHINESE ACADEMY OF SCIENCES

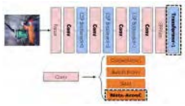
YOLOv5 Based Pedestrian Safety Detection in Underground Coal Mines

Yang Zhang[1,2] and Yimin Zhou[1]

[1]Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, China

[2]University of Chinese Academy of Sciences, China

- We construct a simulated dataset SDUCM-dataset for pedestrian Safety Detection in UCM (Underground Coal Mines), which can satisfy common safety detection tasks requirement to solve the problem of lack of public coal mine environment dataset.
- YOLO-UCM is well designed to detect whether there are potential safety hazards which can achieve higher efficiency than most one-stage object detectors and maintain comparable accuracy compared to the two-stage object detectors.
- It achieves a delicate balance between the accuracy and speed in UCM environments.



The backbone structure of the YOLO-UCMs.

Way To Innovation

ThB4(2) 14:15-14:30

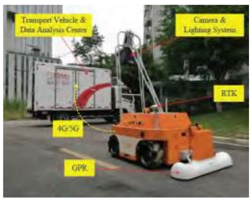
Algorithm for Crack Segmentation of Airport Runway Pavement under Complex Background based on Encoder and Decoder

Haifeng Li, Pan Jing and Rui Huang

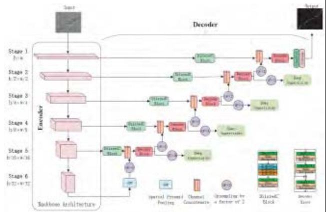
College of Computer Science and Technology, Civil Aviation University of China, China

Zhongcheng Gui

Shanghai Guimu Robot Co. Ltd., Shanghai, China



Airport Runway Inspection Robot



Our Proposed CNN Model for Crack Segmentation

ThB4(3) 14:30-14:45

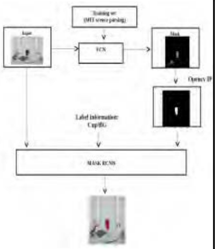
Fully Convolutional Networks for Automatically Generating Image Masks to Train Mask R-CNN

Hao Wu [1,2*], Jan Paul Siebert [2], and Xiangrong Xu [1]

[1]School of Mechanical Engineering, Anhui University of Technology, China

[2]School of Computing Science, University of Glasgow, UK.

- Proposes a novel automatically generating image masks method for the state-of-the-art Mask R-CNN deep learning method
- Implements a fully convolutional networks (FCN) based segmentation network to output object image masks for Mask RCNN object detection
- Proposed method can obtain the image masks automatically with an over 90% mean of average precision (mAP) for segmentation.



ThB4(4) 14:45-15:00

A New Segmentation Method to Preserve the Underlying Image Features: U-Net with Multi-scale Pooling

Yuming Liu, Gongping Chen and Yu Dai

Institute of Robotics and Information Automation, Nankai University, China

- Research objective:
  Segmentation of bladder ultrasound image
- Current problem:
  low ultrasound image quality, irregular changes of the bladder
- Our purpose:
  U-net with Multi-scale Pooling and Dice and Cross-Entropy loss

ThB4(5) 15:00-15:15

Towards a Multispectral RGB-IR-UV-D Vision System — Seeing the Invisible in 3D

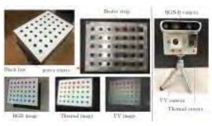
Tanhao Zhang, Luyin Hu and David Navarro-Alarcon

MECHANICAL ENGINEERING, The Hong Kong Polytechnic University, Hong Kong Special Administrative Region

Lu Li

MECHANICAL ENGINEERING, Chinese Academy of Sciences, China

- A Newly designed Multispectral Calibration Tool
- Methods of alignment of 3D Multispectral Images
- Evaluation of the calibration
- Test and experiment for automatic 3D image alignment

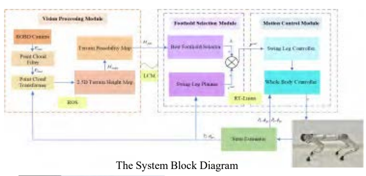


Calibration tool and System

ThB4(6) 15:15-15:30

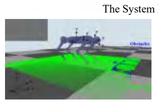
Vision-based Terrain Perception of Quadruped Robots in Complex Environments

Kexin Wang, Teng Chen, Jian Bi, Yibin Li and Xuewen Rong



The System Block Diagram

Using a quadruped robot which equipped with a depth camera to realize the perception of environmental terrain. Terrain height map is constructed based on point cloud data, and terrain passable scheme is determined by potential field algorithm, which provides foothold selection for robot motion planning. By integrating motion and depth vision, the robot can automatically perceive and adapt to the environment and terrain.



2.5D Terrain Height Map

The robot surmounted the obstacles smoothly

ThB5: Surgical Robots II

Session Chairs: Changsheng Li and Zhao Guo

Room : Nan Hai Room, 3/F, 14:00-15:30, Thursday, December 30, 2021

ThB5(1) 14:00–14:15

Can a Tesla Turbine be Utilised as a Non-Magnetic Actuator for MRI-Guided Robotic Interventions?

David Navarro-Alarcon, Luiza Labazanova, Man Kiu Chow and Kwun Wang Ng
The Hong Kong Polytechnic University
The Chinese University of Hong Kong

- A non-magnetic actuator to drive MRI-guided robots is presented
- The motor design is based on a Tesla turbine
- Its rotational motion is powered with pneumatics and measured with fibre optics
- Experiments validate the proposed idea

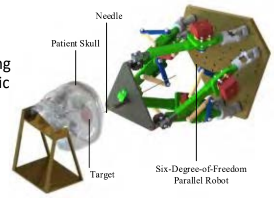
Proof-of-concept prototype

ThB5(2) 14:15–14:30

Pneumatically Actuated MR-Safe Parallel Robot for Deep Brain Stimulation Electrode Implantation

Weihang Huang[1], Shenghao Dai[1], Anze Xu[1], Xianyi He[2], Shaoping Huang[3], and Anzhu Gao[3]
1. The School of Mechanical Engineering, Shanghai Jiao Tong University, China
2. The Department of Automation, Shanghai Jiao Tong University, China
3.The Institute of Medical Robotics, Shanghai Jiao Tong University, China

- A pneumatically actuated MR safe parallel robot for deep brain electrode implantation.
- A 6-DOF parallel robot is developed using six slider-crank mechanisms for prismatic motions.
- Inverse kinematics is built to investigate its workspace and achieve the precise control.
- The average error is 0.11 mm.

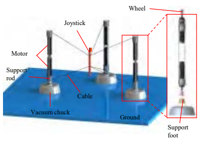


ThB5(3) 14:30–14:45

Preliminary Design of a Reconfigurable Cable-Driven Parallel Haptic Device Towards Robot-Assisted Surgery

Fansheng Meng, Changsheng Li*, Hao Wen, Rui Ma and Xingguang Duan
Department of Mechatronical Engineering, Beijing Institute of Technology, China
Weijun Zhang
Department of Beijing TINAVI Medical Technology Co., Ltd, China

- A novel reconfigurable cable-driven parallel haptic device with variable workspace and simple structures is proposed.
- The reduced inertia/weight of terminal and disturbance of the workspace are beneficial for operating.
- The rods can be fixed on the smooth surface freely to achieve the desired workspace.



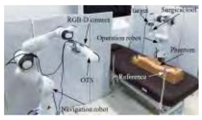
Mechanical design of the haptic device

ThB5(4) 14:45–15:00

Development of an Intra-Operative Active Navigation System for Robot-Assisted Surgery

Yiyang Meng, Yugen You, Pengxiu Geng, Zhichao Song, Yanding Qin
College of Artificial Intelligence (Tianjin Key Laboratory of Intelligent Robotics), Nankai University, China
Institute of Intelligence Technology and Robotic Systems, Shenzhen Research Institute of Nankai University, China

- An active navigation system was proposed to address the intra-operative vision occlusion.
- The proposed active navigation system includes multi-DOF robot, optical tracker and RGB-D camera.
- The static and dynamic positioning accuracy of OTS were investigated.
- An occlusion strategy was developed and experimentally tested.



The prototype of the active navigation system

ThB5(5) 15:00–15:15

Design and Simulation Experiments of a VR Based Tele-operated Surgical Robot System

Haiyuan Li*, Linlin Cui, Yuxuan Qiu, Lutao Yan
Beijing University of Posts and Telecommunications (BUPT), China
Qinjian Zhang
Beijing Information Science and Technology University, China

- A VR based master-slave heterogeneous minimally invasive surgical system as well as flexible robot instruments is presented.
- Master-slave intuitive and interactive control based on ROS and VR are designed.
- Simulation experiments with VR hardware are performed.

ThB5(6) 15:15–15:30

Enhanced Epidural Tissue Perception for Pediatric Patients by An Interactive Lumbar Puncture Simulator

Yuling Li and Hongbing Li
Department of Instrument Science and Engineering, Shanghai Jiao Tong University, China
Jing Zhang and Dingkun Gui

- This paper presents a novel training simulation system for spinal puncture surgery based on virtual reality technology and haptic feedback.
- The system allows the user to adjust the posture of the simulated probe by rotating the head and feel the spinal puncture force through a force feedback device.

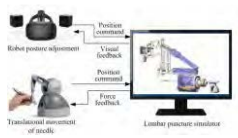


Diagram for lumbar puncture simulation.

ThPo6: Poster Session VI

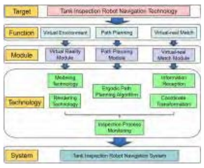
Room : Foyer, 1/F, 15:30-15:50, Thursday, December 30, 2021

ThPo6(1) 15:30–15:50

Design of Tank Inspection Robot Navigation System Based on Virtual Reality

Hengyang Mu, Yifei Li, Diansheng Chen,
Jiting Li and Min Wang
Institute of Robotics, Beihang University, China

- 3D modeling and rendering of the internal scene of the storage tank
- Full traversal path planning algorithm based on Matlab
- Match the pose of the virtual model and the real robot based on information and coordinate transformation
- Human-computer interaction interface design



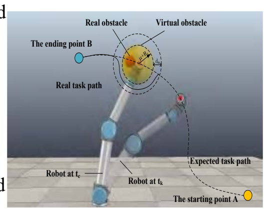
Tank inspection robot system overall technical route

ThPo6(2) 15:30–15:50

Human-machine security collaboration based on virtual collision sensor

Jianhua Zhang (Member), Hao Zhou, Yan Zhao (Member), Liwei Ci, Yang Lu , Yaonan Zhang, Xuan Liu
School of Mechanical Engineering, Hebei University of Technology, Tianjin, China

- A virtual collision sensor is proposed based on generalized momentum theorem for the master-slave task transformation algorithm.
- This algorithm is suitable for obstacle avoidance in an unknown obstacle environment. It has the advantages of small computation and continuous change of avoidance speed.



The obstacle avoidance method

ThPo6(3) 15:30–15:50

Exploring the Spatial Correlation of Shadowing in RF-based Device-Free Localization by Block Sparse Bayesian Learning

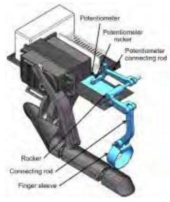
Jiaju Tan[1], Xin Zhao[1], Xuemei Guo[2] and Guoli Wang[2]
[1] Nankai University, Nanjing, China
[2]Sun Yan-sen University

ThPo6(4) 15:30–15:50

Mechanical Design of a Supernumerary Robotic Finger for Grasping Abilities Compensation

Xuwei Lin, Xiaohui Xiao and Zhao Guo
School of Power and Mechanical Engineering, Wuhan University, China

- A supernumerary robotic finger (SRF), which is portable and wearable
- Compensate grasping abilities by a bionic mechanical finger
- Control the mechanical finger by obtaining the posture of the user's little finger
- Use mechanical structure instead of sEMG signal to obtain posture

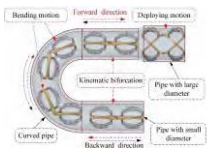


The SRF for grasping abilities compensation

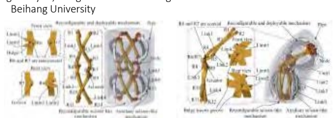
ThPo6(5) 15:30–15:50

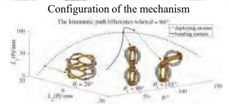
A Reconfigurable and Deployable Mechanism for In-pipe Manipulation Robot

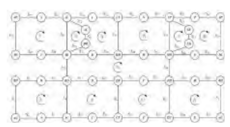
Tianye Xu, Shengnan Lyu*, Hang Xiao and Xilun Ding
Beihang University



Motion process of the mechanism in pipe


Configuration of the mechanism


Kinematic path of the mark point


Screw constraint topological diagram of the mechanism


Movement of the mechanical prototype

ThPo6(6) 15:30–15:50

A Novel Unmanned Surface Vehicle with 2D-3D Fused Perception and Obstacle Avoidance Module

Zhe Chen[1], Tao Huang[1], Zhenfeng Xue[1,2], Zongzhi Zhu[3], Jinhong Xu[1] and Yong Liu[1,2]

Unmanned surface vehicles (USVs) are important intelligent equipment that can accomplish various tasks on open area marine. During operation, environmental perception and obstacle avoidance is of vital significance to its autonomy. In this paper, we propose a novel USV equipped with fused perception and obstacle avoidance mo-dule that contains robust perception, localization and effective obstacle avoidance strategy.The new module is named Three-Dimensional Perception Module (PMTD), which utilizes camera and LiDAR to integrate multi-dimensional environmental information. It is able to detect, identify and track target objects in the process of autonomous travel. The localization precision achieves a centimeter-level with GPS and IMU devices. Meanwhile, the obstacle avoidance strategy allows the USV to efficiently keep away from static and dynamic floating objects in water areas. Through real-world experiments, we show that with the help of the proposed module, the USV can complete stable and autonomous operation and obstacles avoidance path planning even without any manual intervention. This indicates the strong ability of the module in autonomous driving for USVs.

ThPo6: Poster Session VI (cont.)

Room : Foyer, 1/F, 15:30-15:50, Thursday, December 30, 2021

ThPo6_2(7) 15:30–15:50

Quadrotor Trajectory Planning for Visibility-aware Target Following

Lele Xi[1], Xinyi Wang[2], Yulong Ding[3], Yue Wei[3], Zhihong Peng[1] and Ben M. Chen[2]
1. School of Automation, Beijing Institute of Technology, China
2. Department of Mechanical and Automation Engineering, The Chinese University of Hong Kong, China
3. Peng Cheng Laboratory, China

- Target following
- Visibility-aware
- Smooth quadrotor trajectory planning
- Cluttered environment

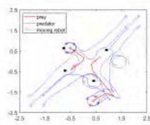
See the experimental video

ThPo6_2(8) 15:30–15:50

A New Scheme for Cooperative Hunting Tasks with Multiple Targets in Dynamic Environments

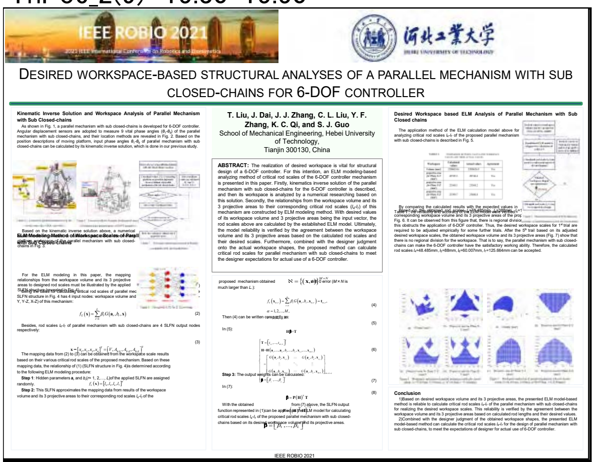
Ruikun Hu and Ning Tan
School of Computer Science and Engineering, Sun Yat-sen University, China
Fenglei Ni
State Key Laboratory of Robotics and Systems (HIT), China

- A new scheme for cooperative hunting tasks with multiple targets in dynamic environments is proposed.
- The multi-target k-WTA algorithm achieves the task allocation for hunting multiple targets with high efficiency.
- The wolf-pack-particle-based model guides robots to cooperatively hunt targets and achieves dynamic obstacle avoidance.

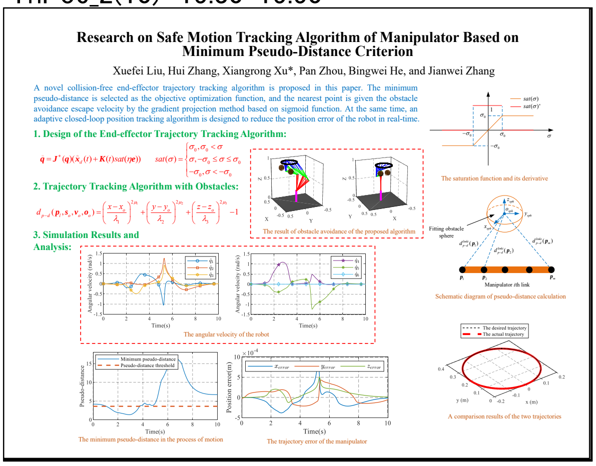


Trajectories of hunting in dynamic environments.

ThPo6_2(9) 15:30–15:50



ThPo6_2(10) 15:30–15:50



ThPo6_2(11) 15:30–15:50

A Distributed Persistent Coverage Algorithm of Multiple Unmanned Aerial Vehicles in Complex Mission Areas

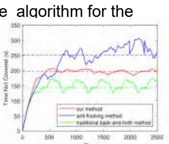
Mengge Zhang, Huiming Li, Jie Li, and Xiangke Wang
College of Intelligence Science and Technology,
National University of Defense Technology, China

•Design a distributed area persistent coverage algorithm for the multi-UAV system.

•Consider the detection probability of the sensor and the importance of different areas.

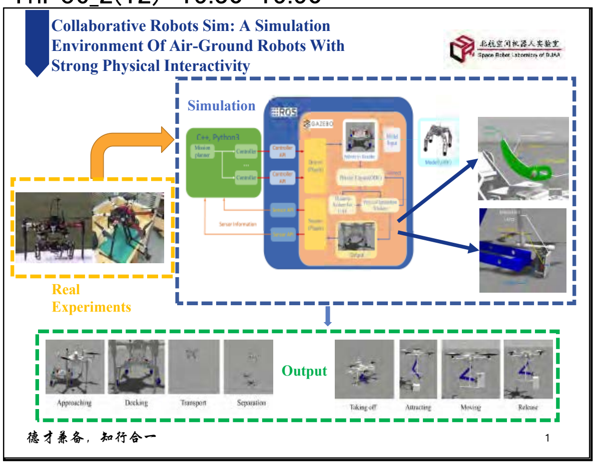
•Use the distributed anti-flocking method to among UAVs.

- Simulations show that the algorithm can achieve continuous and stable coverage of the task area.



Average uncovered time for different algorithms

ThPo6_2(12) 15:30–15:50



ThPo6: Poster Session VI (cont.)

Room : Foyer, 1/F, 15:30-15:50, Thursday, December 30, 2021

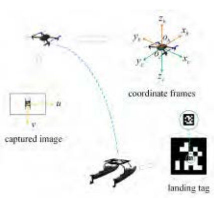
ThPo6_3(13) 15:30–15:50

Autonomous Landing of a Rotor Unmanned Aerial Vehicle on a Boat Using Image-Based Visual Servoing

Lingjie Yang, Zhihong Liu, Xiangke Wang, Guanzheng Wang, Xinyu Hu, Yexun Xi

College of Intelligence Science and Technology, National University of Defense Technology, China

- Propose an IBVS method for a rotor UAV to land on a boat with a downward-looking camera.
- The virtual camera method is adopted to compensate the effect of UAV's attitude changes.
- A nested 2D landing tag is designed to ensure the detection within a large altitude range.
- Introduce Kalman filter to optimally estimate the position of the feature point with observation noise.
- Both simulation experiments based on Gazebo and field experiments based on the deck simulation platform are conducted



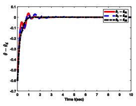
ThPo6_3(14) 15:30–15:50

Trajectory Tracking Control of Uncertain Euler-Lagrange Systems: A Robust Control Approach

Xingxiu He, Maobin Lu and Fang Deng

School of Automation, Beijing Institute of Technology, China

- A robust controller instead of adaptive controller is proposed
- A strict Lyapunov function is constructed
- Use the relative position and relative velocity information in the controller



Position tracking error

ThPo6_3(15) 15:30–15:50

Collision-free Trajectory Generation for UAV Swarm Formation Rendezvous

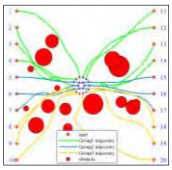
Weiming Qing and Yongxin Yin

CH UAV Department, China Academy of Aerospace Aerodynamics, China

Hao Chen and Xiangke Wang

College of Intelligence Science and Technology, National University of Defense Technology, China

- Solve a UAV swarm rendezvous problem with spatial-temporal and safe-critical constraints using two-stage strategies.
- Offline planning provides a near-optimal solution for real-time online decision-making, which is based on ACO with elite strategy and minimum-snap algorithm with safe corridors.
- Online planning incorporates the zeroing control barrier function constraints and the offline trajectories for absolute collision avoidance.



The UAV swarm's formation rendezvous

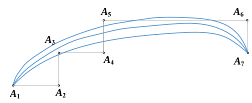
ThPo6_3(16) 15:30–15:50

Path Planning Based on Segmented Bezier Curves and A* Algorithm for Mobile Robot

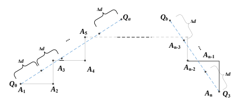
Xiangrui Meng[1,2], Shuang Liang[1], Zhiqiang Cao[1], Zhonghui Li[3], Shuo Wang[1]

1. The State Key Laboratory of Management and Control for Complex Systems, CASIA, Beijing, China.
2. Information Science Academy, China Electronics Technology Group Corporation, Beijing, China.
3. Beijing Engo Technology Co. Ltd, Beijing, China.

- An optimized path planning method based on segmented Bezier curves and A* algorithm for mobile robot is presented. A* algorithm is used to guide the generation of Bezier curves, while the segmented Bezier curves are used for smoothing the A* path.
- The determination of segment points, control points and the optimization of path selection are crucial parts of the method. The optimized Bezier curve for each segmented A* path is selected according to the fitting index with constraints.
- The proposed method is verified by the experiments, which can deal with dynamic interference.



Bezier curves fitting A* path



The selection of control points

ThPo6_3(17) 15:30–15:50

Distributed Entrapping Control of Multiple Second-order Mobile Agents Under a Directed Network

Min Deng, Xiao Yu, and Weiyao Lan*

Department of Automation, Xiamen University, China.

- The distributed entrapping control problem of the second-order multi-agent systems under a directed network.
- Time-varying entrapping formation has elasticity and rotation, whose parameter is only known to some agents.
- Distributed observer is used to estimate the formation shape parameter
- A dynamic control law is proposed under the position and velocity measurements
- Simulation example illustrates the theoretic result.

ThPo6_3(18) 15:30–15:50

Bionic Control Method for a Multi-Motor Joint Based on the Physiological Muscle Model

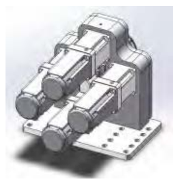
Liyan Chen, Sheng Bi, George Zhang, Shujia Qin*, Ning Xi

Shenzhen Academy of Robotics, China

Yong Zhang

National Astronomical Observatories / Nanjing Institute of Astronomical Optics & Technology, Chinese Academy of Sciences, China

- Bionic robots have recently displayed a promising prospect for broad applications
- There is still a gap between the current progress and the biological feature resemblance of energy efficiency and natural compliance
- This paper studies the bionic control method for a multi-motor joint based on the kinetics of biological muscle components and realizes the biological feature resembled motion



Multi-motor joint design

ThC1: Motion Planning III

Session Chairs: Liwei Zhang and Yanding Qin

Room : Phoenix Ballroom, 1/F, 15:50-17:05, Thursday, December 30, 2021

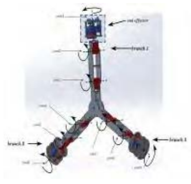
ThC1(1) 15:50–16:05

Kinematic Analysis and Gait Planning of a Three-branch Relative Robot for On-orbit Assembly

Shengli Yang[1], Deshan Meng[1], Ping Jiang[2], Wenlong Yang[1], Wenqi Wan[1], Zhigang Wu[1]

1.School of Aeronautics and Astronautics, Sun Yat-Sen University, Shenzhen
2. the Intropytech Co.,Ltd

- Modeling a three-branch relative robot for assembly
- The kinematics model and the inverse kinematics solution method are given
- The three-branch relative robot gait and the corresponding gait planning algorithm are defined
- Gait planning algorithms are verified by simulation and experiment



Three-branch Relative Robot Model

ThC1(2) 16:05–16:20

Time-Optimal Trajectory Planning for Robots with Identified Dynamics

Shize Lin, Ze Wang, Chuxiong Hu and Yu Zhu
Mechanical Engineering, Tsinghua University, China

- Time optimal trajectory planning of robots is formulated as an optimization problem utilizing identified dynamics
- Both jerk and torque limits are included as non-convex constraints
- The optimization is discretized and iteratively solved by sequential convex programming
- Real-world experiments are conducted on a 6-DOF industrial robot

Experimental setting

ThC1(3) 16:20–16:35

Synthesis and Online Re-planning Framework for Time-Constrained Behavior Tree

Chuanxiang Gao, Yu Zhai, and Ben M. Chen
Mechanical and Automation Engineering,
The Chinese University of Hong Kong, Hong Kong
Biao Wang
Nanjing University of Aeronautics and Astronautics
Nanjing, Jiangsu, China

- Behavior Tree
- Time-Constrained
- Automatically Generate
- Online Re-plan

The scenario of search and rescue tasks with two UAVs.

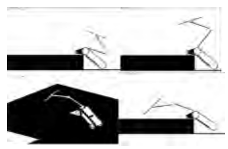
ThC1(4) 16:35–16:50

A movement planning and control method of special robot over obstacle based on centroid monitoring

Yong Tao [1, 2, *], He Gao [2], Yufang Wen [1], Jiangbo Lan [1]

1.School of Mechanical Engineering & Automation, Beihang University, China
2.Research Institute of Aero-Engine, Beihang University, China

- Semi-autonomous obstacle climbing control
- The centroid kinematics model of the robot with variable structure.
- The non-line-of-sight obstacle height estimation method.
- The obstacle-climbing movement planning and control method



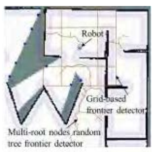
Simulation of robot climbing obstacles

ThC1(5) 16:50–17:05

Hybrid Frontier Detection Strategy for Autonomous Exploration in Multi-obstacles Environment

Guangjin Xu, Liwei Zhang, Meng Chen and Bingwei He

- Rapidly-exploring Random Tree (RRT) algorithm is widely used in path planning, while the RRT is inefficient for robotic exploration in large-scale environments with multi-obstacles and narrow entrances.
- Here, we propose a Hybrid Frontier Detection (HFD) strategy for autonomous exploration which incorporates a variable step-size random tree global frontier detector, a multi-root nodes random tree frontier detector, and a grid-based frontier detector algorithm.
- Compared with the traditional RRT-based strategy, the exploration time and traveling length of the proposed HFD strategy are respectively decreased by over 15% and 12% in the simulation environment and decreased by over 14% and 11% under the same experimental conditions in the experimental environment. The results indicate that the HFD strategy effectively solves the problem of autonomous exploration in the environment with multi-obstacles and narrow entrances.



ThC2: Mechanism Design

Session Chairs: Fei Wang and Xiao Liang

Room : Nan Shan A, 3/F, 15:50-17:05, Thursday, December 30, 2021

ThC2(1) 15:50–16:05

Mechanical Design of a Metamorphic Robot for High-voltage Transmission Line Insulator Detection

Hui Yuan[1,2,3], Bingbing Yuan[2,3,4], Hongguang Wang[2,3,*], Yifeng Song[2,3]

[1]School of Mechanical Engineering and Automation, Northeastern University, Shenyang 110004, China

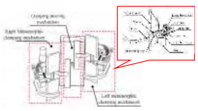
[2]State Key Laboratory of Robotics, Shenyang Institute of Automation, Chinese Academy of Sciences, Shenyang 110016, China

[3]Institutes for Robotics and Intelligent Manufacturing, Chinese Academy of Sciences, Shenyang 110169, China

[4]University of Chinese Academy of Sciences, Beijing 100049, China

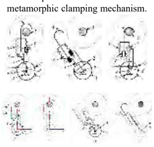
Mechanical design

An insulator detection metamorphic robot was designed for the insulator string on high-voltage transmission line.



Metamorphic and force

The configurations and static force model were analyzed for the metamorphic condition of the metamorphic clamping mechanism.



Prototype

A prototype is developed to carry out trafficability, climbing performance and adaptability experiments. This experiments show that the insulator detection metamorphic robot has the advantages of lightweight, good adaptability, and compact structure.

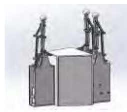
ThC2(2) 16:05–16:20

Mechanism Design and Kinematic Analysis of a Robotic Modular Finger and Reconfigurable Hand

Fei Wang , Duanling Li and Haiyuan Li

Beijing University of Posts and Telecommunications, China

- A fully driven finger and reconfigurable hand of a robot is designed.
- The kinematics of a single finger is analyzed and grasping workspace is obtained.
- The spring and the grasping range adjusting hole are integrated in the finger mechanism, resulting in simple structure, low production cost, and the adaptive grasping ability.



Finger and hand

ThC2(3) 16:20–16:35

Design of a Gripper for Cable Assembly with Integrated In-hand Cable Manipulation Functions

Yanling Zhou, Xin Jiang, Dayuan Chen, Yuhao Guo

Mechanical Engineering and Automation, Harbin Institute of Technology, Shenzhen, China

Yunhui Liu

Mechanical and Automation Engineering, The Chinese University of Hong Kong, China

- With functions for in-hand manipulating the cable segments
- Gripping, twisting and sliding the cable
- Cable recognition

ThC2(4) 16:35–16:50

Underactuated Picking Gripper for Grasping and Cutting Citrus

Zhaojiang Yu, Jianjun Yuan, Dianzhen Guo, Liang Du, Sheng Bao

Shanghai Robotics Institute, Shanghai University, China

Shugen Ma

Department of Robotics, Faculty of Science and Engineering, Ritsumeikan University, Japan

- By designed the differential gear train enables the gripper to complete two actions by a motor.
- By designed an underactuated form requires no force sensor but completes a constant force control.
- By designed the RRSM, we can adjust the grip force according to the variety fruit.

Prototype of the picking gripper

ThC2(5) 16:50–17:05

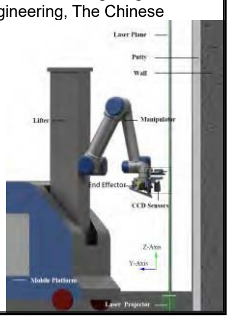
High-precision end-tip positioning system for automatic interior finishing process based on laser level

Dayuan Chen[1], Yexi Chen[1], Xin Jiang[1] and Yunhui Liu[2]

[1]Harbin Institute of Technology (Shenzhen), Shenzhen, Guangdong, China

[2]Department of Mechanical and Automation Engineering, The Chinese University of Hong Kang, Hong Kong, China

- Proposed a high-accuracy, high-speed and low-cost positioning method for control the quality of interior finishing operation.
- Combined a customized end-effector to improve performance of putty applying.
- Designed a finding plane algorithm to adaptive the laser plane.



ThC3: Mobile Robots II

Session Chairs: Yang Gao and Hesheng Wang

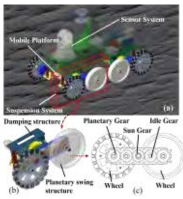
Room : Nan Shan B, 3/F, 15:50-17:05, Thursday, December 30, 2021

ThC3(1) 15:50–16:05

Analysis on Ride Comfort of a Novel Eight Wheel Vehicle

Yu Zhang,Wenchuan Jia, Jianjun Yuan, Shugen Ma and Sheng Bao
School of Mechatronics Engineering and Automation, Shanghai University, China
Shiqiang Wang, Sha He and Peihang Yu
Safety Environment Quality Surveillance and Inspection Research Institute, CNPC Chuanqing Drilling & Exploration, China

- Based on the proposed eight-wheel vehicle, the dynamic model of this vehicle is established.
- The simulations are carried out to discuss the factors affecting ride comfort.
- The ride comfort of the optimized eight-wheel vehicle has been significantly improved.



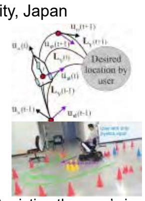
Eight-wheel Vehicle

ThC3(2) 16:05–16:20

A Geometric Assistive Controller for the Users of Wheeled Mobile Robots without Desired States

Seyed Amir Tafrishi, Ankit A. Ravankar, Salazar Jose and Yasuhisa Hirata
Robotics Department, Tohoku University, Japan

- Developing a new Darboux-frame-kinematics on the frame of vehicle
- Proposing safety conditions and problem statement
- Developing the differential-geometry-based controller
- Analyzing the performance of the wheeled mobile robot behavior with and without assistive control



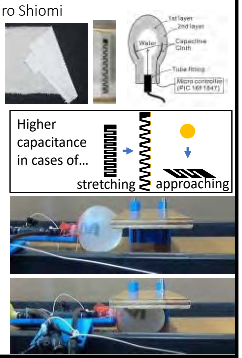
Assisting the user's inputs without having any desired states

ThC3(3) 16:20–16:35

Stretchable Multi-modal Sensor using Capacitive Cloth for Soft Mobile Robot Passing through Gap

Takashi Takuma, Koki Haruno, Kosuke Yamada, Hidenobu Sumioka, Takashi Minato and Masahiro Shiomi

- Multi-modal soft sensor
  - made of silicone embedding a conductive fabric
  - gets higher capacitance not only in stretching but also object approaching
- Soft robot driven by water
  - embeds the conductive fabric in silicone
  - estimates the shape of the obstacle through which the robot passes



ThC3(4) 16:35–16:50

A Visual SLAM Algorithm Based on Dynamic Feature Point Filtering

Sen Kang, Yang Gao, Kunpeng Li, Wangxin Cao
Chang'an University, Xi'an, China

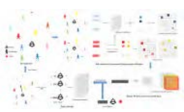
- The purpose of this paper is to improve the positioning accuracy of the VSLAM algorithm in a dynamic environment
- YOLOv4-Tiny target detection network recognizes dynamic objects
- LK optical flow method and Meanshift algorithm clusters velocities feature points
- The experimental results in the public dataset and real road environment show that the algorithm proposed can improve the positioning accuracy in a dynamic environment

ThC3(5) 16:50–17:05

Robot Navigation with Interaction-based Deep Reinforcement Learning

Yu Zhai and Yanzi Miao
School of information and control engineering, China University of mining and technology, China
Hesheng Wang
Department of Automation, Shanghai Jiao Tong University, China

- We propose a novel method base reinforcement learning of robot navigation called **robot human interaction reinforcement learning** (RHIRL)
- We propose a **new environment representation** method based attention mechanism which implicitly includes the **potential interaction.**
- Excellent navigation performance in **dynamic and unfamiliar environment**.



The structure of RHIRL

ThC4: Image Processing

Session Chairs: Yaowei Liu and Ningbo Yu

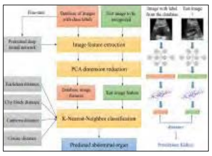
Room : Liang He Room, 3/F, 15:50-17:05, Thursday, December 30, 2021

ThC4(1) 15:50–16:05

Automatic Recognition of Abdominal Organs in Ultrasound Images based on Deep Neural Networks and K-Nearest-Neighbor Classification

Keyu Li[1], Yangxin Xu[1], Ziqi Zhao[2] and Max Q.-H. Meng[1,2]
[1] Department of Electronic Engineering, The Chinese University of Hong Kong, Hong Kong, China
[2] Department of Electronic and Electrical Engineering, Southern University of Science and Technology, China

- A method for automatic recognition of abdominal organs in ultrasound images is proposed to make routine ultrasound imaging process easier and faster.
- We employ fine-tuned deep neural networks and PCA for feature extraction, and use a k-NN classifier to recognize the abdominal organs in the image.
- Experimental results show that with minimal training effort, our method can "lazily" recognize six abdominal organs from the ultrasound images in real time.

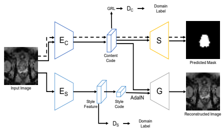


ThC4(2) 16:05–16:20

Unseen Domain Generalization for Prostate MRI Segmentation via Disentangled Representations

Ye Lu[1], Xiaohan Xing[1] and Max Q.-H. Meng[1,2,*]
[1] The Chinese University of Hong Kong, Hong Kong, China
[2] Southern University of Science and Technology, Shenzhen, China

- A novel **d**isentangled-**r**epresentation based **d**omain **g**eneralization (DRDG) framework is proposed for Prostate MRI segmentation.
- Domain-invariant features are separated for unseen domain generalization by sharing content encoder with segmentation networks.
- Two domain discriminators are designed to regularize the representation disentanglement learning.
- Experimental results show the effectiveness of our method, outperforming many SOTA methods.



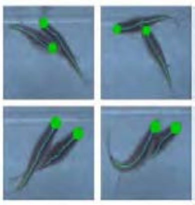
Overview of our proposed DRDG framework

ThC4(3) 16:20–16:35

Zebrafishtracker: A multi-zebrafish tracking algorithm can effectively solve cross occlusion

Zhenhua Fu, Yiwen Wang, Xin Zhao, Mingzhu Sun
Institute of Robotics and Automatic Information System, Nankai University, China

- Zebrafishtracker can effectively solve the problem of cross occlusion in the tracking of multiple zebrafish.
- The instance segmentation and skeleton analysis strategies are used to improve the accuracy of crossover detection.
- 2D tracking of zebrafish is realized based on identity information. The results show that in two relatively complex videos, MOTA of our algorithm in the top-view reaches more than 95%.

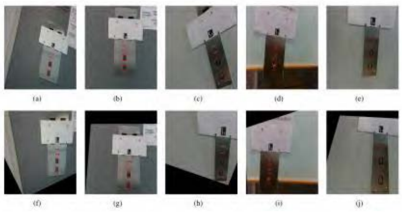


Cross case of skeleton and head detection

ThC4(4) 16:35–16:50

Autonomous Removal of Perspective Distortion of Elevator Button Images based on Corner Detection

Nachuan Ma[1], Jianbang Liu[2], and Delong Zhu[2]



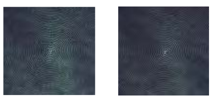
ThC4(5) 16:50–17:05

Blurring Feature Analysis of Microscopic Images Based on Deep Learning

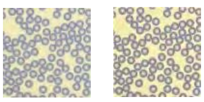
Yangjie Wei*, Weihan Hou
College of Computer Science and Engineering, Northeastern University

- We proposed a blurring feature analysis system based on StyleGAN. The improved StyleGAN model was trained using the optical image of a Gaussian light source, and an ideal blurring image generation model based on StyleGAN was obtained.
- Through the automatic learning of the image features with dynamic parameters, a series of ideal blurring images of the Gaussian light source are generated and the blurring kernel of the optical imaging system is extracted.
- A high-resolution image reconstruction method with respect to large-scale visible light images is proposed based on the extracted blurring kernel and the learnable convolutional half-quadratic splitting and convolutional preconditioned Richardson (LCHQS-CPCR) neural network model.

Comparison of real diffraction image and generated image



Comparison of microscopic image reconstruction result



ThC5: Planning & Control III

Session Chairs: Yuliang Zhao and Shan Guo

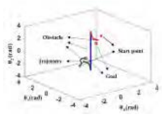
Room : Nan Hai Room, 3/F, 15:50-17:05, Thursday, December 30, 2021

ThC5(1) 15:50–16:05

Obstacle Avoidance Strategy of Improved APF Method in C-space

Jingshen zhao and Ying Wang
School of Mechanical Engineering, Inner Mongolia University of Technology, China
Lixing Jin
School of Mechatronic Engineering, Beijing Institute of Technology, China

- This method is more compatible: the advanced improvements of the mobile robot APF method can be transplanted on C-APF.
- The calculation is brief.
- The trajectory calculated by C-APF is better.
- C-APF is more robust: this method is inclusive to the local minimum problem of workspace.



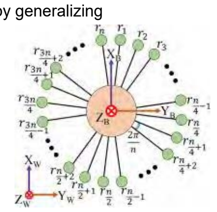
A Trajectory Generated by Method of C-APF

ThC5(2) 16:05–16:20

Formulation of Fault-tolerant Control for Hyper-redundant Multi-copters

Takuro Inohara
Graduate School of Frontier Sciences, The University of Tokyo, Japan
Keigo Watanabe and Isaku Nagai
Graduate School of Natural Science & Technology, Okayama University, Japan

- Hyper-redundant multi-copters are defined by generalizing the number of rotors on multi-copters
- Polygo-copters, a type of hyper-redundant multi-copters, is defined
- The PNPN and PPNN structures are introduced as the structures of aircrafts
- The PNPN structure is found to be superior from the viewpoints of fault-tolerance



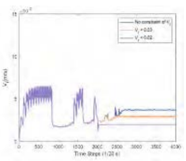
ThC5(3) 16:20–16:35

Simultaneous Gait Generation and Path Following Control of Snake Robot Using MPC

Yichen Liang[1], Chao Ren[1], Yongchen Tang[2], Xiaohan Li[1] and Shugen Ma[1,3]

[1]School of Electrical and Information Engineering, Tianjin University, Tianjin, China.
[2]Key Lab of Intelligent Data Information Processing and Control of Hebei Province, Tangshan University, Tangshan, China
[3]Department of Robotics, Ritsumeikan University, Shiga, Japan

1) The simultaneous gait generation and path following control with given forward velocity are investigated under the MPC scheme.
2) The cost function design in MPC is investigated for snake robot to realize the path following control and forward velocity maximization.
3) The forward velocity is controlled by viewing the desired velocity as one constraint.
4) Simulation results verify the effectiveness of the proposed control scheme.

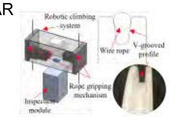


ThC5(4) 16:35–16:50

Groove Profile Design and Durability Analysis of Sheave for Robotic Wire Climber System

Colin Pak Yu Chan, Keng Huat Koh, Kin Hei Shiu, Chun Ho So, Musthafa Farhan and King Wai Chiu Lai
Department of Biomedical Engineering, City University of Hong Kong, HKSAR
Kenny Pui Ching Yeung, Michelle Pui Yee Lau and Pak Kin Cheung
Customer Maintenance Service Department, The Hong Kong and China Gas Company Limited, HKSAR

- Design a ***robotic wire rope climber system*** for 40-storey building to *perform the riser inspection operation*
- Use *Nylon sheave* with **novel** *V-grooved profile*
- Obtain **over 3.5 times of payload** to *weight ratio*
- Sustain the *rope-to-sheave traction after* **1-km of travel distance**



Author Index

Index of Authors

CC: Session Chair

- D -

- F -

- G -

- H -

- I -

- J -

- K -

- L -

- M -

- T -

- U -

- V -

- W -

- X -

- Y -

- Z -

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