Conference Digest
IEEE/ASME International Conference on Advanced Intelligent Mechatronics
Welcome Message

On behalf of the Organizing Committee, we are pleased and honored to welcome you to the VIRTUAL 2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM 2020). AIM is an offspring flagship conference of the IEEE/ASME Transactions on Mechatronics (TMECH). The success of the past AIM conferences has made it a widely anticipated annual event. Although facing the unprecedented COVID-19 pandemic, under the wise guidance of the AIM Advisory/Steering Committees, we offer this nineteenth AIM conference with the hope that it will match the high standard of excellence set by its predecessors.

Reflecting the international character of the AIM community, we have a diverse and exciting technical program. The AIM 2020 event features three plenary and four keynote speakers from North America, Europe, and Asia, who will share a variety of fascinating and exciting developments in advanced mechatronics. The successful introduction of the inaugural edition of TMECH/AIM Emerging Topics through TMECH/AIM 2020 concurrent submissions received an overwhelming response from the international mechatronics research community with 171 submissions, and 41 were finally included in TMECH publication after two rounds of rigorous review, establishing a seven-month submission-to-print record. AIM 2020 has also initiated for the first time an undergraduate student design competition, attracting 15 submissions by student teams from six countries.

The conference received over 450 high-quality manuscripts and 19 late breaking results posters. Thanks to the great effort by the AIM Conference Editorial Board and TMECH/AIM Emerging Topics Editorial Board, comprising 81 Associate Editors and 492 reviewers (excluding more than 300 peer reviewers for TMECH/AIM Emerging Topics), 302 papers were included in the final program with an acceptance rate of 67%. In addition, the technical program includes the presentation of 8 papers that were published or accepted by TMECH. The AIM 2020 submissions were from 39 countries and the final program consists of 65 technical sessions. Following the AIM tradition, this year’s virtual event offers five high-quality pre-conference technical workshops and three special sessions on emerging topics in mechatronics for infectious diseases, distance learning, and human-robot interactions. The conference also presents two Best Paper Awards: the Best Student Paper Award (for which we received 63 nominations) and the Best Conference Paper Award.

We offer our deep and sincere thanks to the members of the AIM 2020 Organizing Committee who worked hard to make the virtual event possible during the challenging pandemic time. Our final and most heartfelt thanks go to all of you, the international mechatronics community, who enthusiastically get together each year at AIM, for stimulating idea exchanges and professional development. We hope that this virtual AIM 2020 will be an exciting and memorable experience for everyone!

Best,

Jingang Yi, Ph.D.
General Chair

Xiaobo Tan, Ph.D.
Program Chair
Sponsors

State Key Lab of Fluid Power & Mechatronic Systems, Zhejiang University, China

Guimu Robot, Ltd, Shanghai, China

School of Engineering, Rutgers University, Piscataway, New Jersey, USA

University of Texas at Arlington, Texas, USA

AIAA Intelligent Systems Technical Committee

Quanser Consulting Inc.
Navigating AIM 2020

AIM 2020 is entirely online and taking place over Zoom. All live sessions will take place using Eastern Daylight Time (UTC-4:00). For this year’s conference, we will offer several additional resources to enrich the attendee experience. Post-presentation discussions and attendee-to-attendee communication will be supplemented by Slack, whereas a digital alternative to physical posters will be provided by a virtual poster gallery on Mozilla Hubs. We hope that these tools will help you connect with other attendees and allow richer discussions.

Conference Technical Sessions, Plenaries, and Other Live Content

All live AIM 2020 live content will be accessible via Zoom. Look in the online program or in this document for links that will take you directly to sessions. If you are new to Zoom, please visit the following links to help you get started.

For a quick Getting Started guide for Zoom, please visit:

Getting Started – Zoom Help Center

You can test your audio and video setup by connecting to a Zoom Test Call:

Join a Test Meeting - Zoom

Instant Messaging over Slack

Slack provides a convenient way to have text-based discussions with other attendees. Users can participate in public discussions (similar to old IRC-based chatrooms) or communicate privately using direct messages. Public discussions for AIM 2020 are divided into several channels (indicated by # before the channel name) corresponding to topics relevant to the conference. AIM 2020 will provide channels for general discussions, introductions, session discussion, and more.

You can find more information about the AIM 2020 Slack workspace in the #welcome channel.

To join the AIM 2020 Slack workspace, please follow this link:

https://join.slack.com/t/aim2020boston/shared_invite/zt-fd3iegwy-xNOamDjYlvdPECCLUDyA

If you have already joined the workspace, you can sign in here:

https://aim2020boston.slack.com

Virtual Poster Gallery on Mozilla Hubs

While the late breaking results and student design competition poster sessions will take place alongside the morning technical sessions on Tuesday, July 7 and Wednesday, July 8, respectively, we will also provide an alternative way to view and discuss posters through virtual spaces created in Mozilla Hubs. The virtual spaces constructed for the AIM 2020 poster gallery consist of connected rooms that attendees can visit at their leisure. Mozilla Hubs also allows voice chat with nearby attendees, with decreasing volume as the distance between
two attendees increases. This provides a natural way of limiting discussions of the posters to the vicinity of the poster itself.

To get started, please join us on Slack in the #poster-gallery channel, or directly follow this link:

AIM 2020 Virtual Poster Gallery | Hubs by Mozilla

For more information on movement controls within Mozilla Hubs, please visit:

Controls · Hubs by Mozilla

For more information or assistance please contact a volunteer using the #help channel on Slack.

Coffee and Lunch Breaks over Zoom

Please join us for coffee and lunch breaks over Zoom. We will host three large Zoom meetings for coffee and lunch breaks throughout the conference for socializing and discussing the day’s events. Links to these meetings will be provided in the program on Papercept, and will be open to all conference attendees. You are welcome to use these room outside the designated coffee and lunch breaks between each session, as we will keep them open for the duration of the conference.

We will also provide several password-protected private rooms for smaller group meetings over Zoom for your convenience. For more information about scheduling private rooms, please visit the #private-meetings channel on the AIM 2020 Slack workspace or contact a volunteer during conference hours. We encourage the use of Slack direct messages to schedule on-the-spot meetings with other attendees using Zoom or any other video conferencing tool you prefer.
# Committees

## AIM Advisory Committee

<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
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<tr>
<td>Hideki Hashimoto</td>
<td>Chuo University, Japan</td>
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<td>I-Ming Chen</td>
<td>Nanyang Technological University, Singapore</td>
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## AIM Steering Committee

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<td>Martin Buss</td>
<td>TU Munich, Germany</td>
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<td>Jordan Berg</td>
<td>National Science Foundation, USA</td>
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<td>Hiroshi Fujimoto</td>
<td>University of Tokyo, Japan</td>
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<td>Jingang Yi</td>
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<td>Xiang Chen</td>
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<td>Tao Liu</td>
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<td>Kiyoshi Ohishi</td>
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<td>Xiaobo Tan</td>
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<td>Seiichiro Katsura</td>
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<td>Georg Schitter</td>
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<td>Kenn Oldham</td>
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<td>Yang Shi</td>
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<td>Taehyun Shim</td>
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<td>Xu Chen</td>
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<td>Garrett Clayton</td>
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<td>Gursel Alici</td>
<td>Awards Chair</td>
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<td>Se Young (Pablo) Yoon</td>
<td>Registration Chair</td>
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<td>Hiroshi Fujimoto</td>
<td>Conference Editorial Board Chair</td>
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<td>Shigeki Sugano</td>
<td>RAS Liaison Officer</td>
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<td>Hao Liu</td>
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## Program Overview

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<th>Time</th>
<th>Monday 7/6/2020</th>
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<th>Wednesday 7/8/2020</th>
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<td>8:00 - 8:45</td>
<td>Opening Remarks</td>
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<tr>
<td>9:00 - 10:00</td>
<td>Plenary I</td>
<td>Plenary II</td>
<td>Plenary III</td>
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<td>10:00 - 10:15</td>
<td>Break</td>
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<td>10:00 - 10:15</td>
<td>Technical Sessions (Poster Sessions)</td>
<td>Technical Sessions (Student Design Competition)</td>
<td>Awards Ceremony</td>
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<td>10:50 - 11:00</td>
<td>Workshops</td>
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<td>Break</td>
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<td>11:00 - 11:30</td>
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<td>11:30 - 11:40</td>
<td>Keynotes 1 &amp; 2</td>
<td>Keynotes 3 &amp; 4</td>
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<td>11:40 - 12:20</td>
<td>Lunch</td>
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<td>1:30 - 2:45</td>
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Description

Magnetic fields are widely utilized as media for energy conversion and information storage. Harnessing magnetic fields for sensing and control of mechatronic systems is a reliable and efficient means as magnetic fields are invariant to environmental factors such as temperature, pressure, and light, while permitting non-contact and remote functions across multiple non-ferromagnetic mediums. Inspired by the advancements in new materials, sensor fusion technology and embedded computations, the applications of magneto-mechatronic systems are being pushed forward to a new level, advancing a wide variety of subjects being precisely measured, perceived, and manipulated at unprecedented resolution, scale, and speed. Challenges, however, are presented in modeling, sensing and control of magneto-mechatronic systems to meet the continuously increasing demands and emerging applications. The IEEE/ASME AIM2020 Workshop on Advanced Magneto-Mechatronics Systems aims at bringing mechatronic researchers and practitioners from multiple disciplines to discuss emerging fundamental issues in mechatronics from perspectives over a wide spectrum of applications, such as smart actuators, field reconstruction and perception, medical and surgical devices. This Workshop will discuss recent advances, challenges and opportunities in modeling, sensing and control of magneto-mechatronic systems that move forward new technologies in mechatronic systems with more and more ‘smart functions’. Both hardware innovations and methodology developments will be presented, balancing theoretical analysis and modeling with experimental demonstrations and discussions. The AIM Workshop on magneto-mechatronic systems will help better understand the fundamental concepts and theories in formulating magneto problems and determine the major challenges for future magneto-mechatronic systems, as well as identify key mechatronic technologies for meeting these challenges.

Invited Talks

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<tr>
<th>#</th>
<th>Title</th>
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<tr>
<td>1</td>
<td>Magnetic Field Based Sensing and Control of Smart Actuators</td>
<td>Kun Bai</td>
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<tr>
<td>2</td>
<td>Passive Magnetic Field-based Sensing and Localization</td>
<td>Shaohui Foong</td>
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<tr>
<td>3</td>
<td>Magnetic Field Modeling and Sensors for Non-Ferrous Metallic and Biological Objects</td>
<td>Chun-Yeon Lin</td>
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<td>5</td>
<td>Eddy-Current Field Reconstruction and Control Based on Distributed-Parameter Models for Machine Perception and Stimulation</td>
<td>Min Li</td>
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Abstracts

Magnetic Field Based Sensing and Control of Smart Actuators

Smart actuators with dexterous motion and direct force/torque manipulations are central for emerging intelligent systems in a wide range of applications ranging from manufacturing to robotics. Existing actuator systems are primarily built by connecting motors and mechanical linkages to achieve complex motions and external encoders/sensors for position and force control. These systems usually have complex structures which lead to singularities in their motion (multi-DOF systems) and difficulties in direct force/torque manipulations. This talk will present smart actuator designs that can achieve complex motions and precise force/torque manipulations with compact structures and integrated field sensors for efficient low-level sensing and control. Based on the integration of actuation-sensing-control modules and driving algorithms permitting parallel computations, advanced control strategies, such as spindle load compensation, fault detection/remedy algorithms and compliant joint control can be efficiently implemented on the actuator systems. Emerging applications of these smart actuators including conformal printing of curved electronics and master-slave robots will be demonstrated.

Passive Magnetic Field-based Sensing and Localization

Numerous medical and surgical operations, such as minimally invasive procedures, require knowledge of the position and orientation of the target device or instrument inside the body. Currently, tethered embedded vision cameras and diagnostic imaging techniques (CT, X-Rays, MRI) are widely employed to gain instantaneous spatial feedback of the target inside the body. However, these methods can be cumbersome to deploy, limited by onboard power and potentially harmful to the patient under prolonged use. Localization using artificially generated electromagnetic fields (similar to GPS) is possible but are particular difficult to use in the clinical setting due to the need for calibrating and constricting the body with respect to fixed position of the electromagnetic field generator. Another drawback is that the target of interest, which contains the electromagnetic sensor is mechanically and electronically tethered. Here a non-invasive localization system harnessing passive magnetic tracking technology and adapted for clinical use is presented as a viable alternative to contemporary established protocols. This approach addresses the key deficiencies in current electromagnetic localization technology and retains the benefits of field-based localization such as not requiring line of sight, insensitivity to biological tissue and radiation free.

Magnetic Field Modeling and Sensors for Non-Ferrous Metallic and Biological Objects

Magnetic and Eddy-current (M/EC) sensing systems play important roles in a broad spectrum of applications ranging from manufacturing to biomedical engineering and have many advantages, such as long-term reliability, wide measuring range, fast response, and high resolution. The formulation of the M/EC fields is an important step to design analysis and develop these sensing systems. The distributed current source (DCS) method which formulates the axis-symmetrical and three dimensional M/EC fields of non-ferrous metallic and biological objects into first and second order systems for design analysis and development of magnetic sensor based EC and coupled differential coil systems for sensing non-ferrous metallic and biological objects will be introduced in this talk. The state-space representation of M/EC fields in DCS method provides a basis for the subsequent steady state, time dependent, and frequency analysis. One more merit of the DCS method is that this method performs better than FEA for calculations of the weak MFDs generated from the tiny ECDs induced in the biological objects to facilitate the development of low-cost coupled differential coil systems for detection of biological objects.

Optimal control theory has played great roles in robust controller design and state estimation for high-performance servo systems. The associate methods to efficiently solve the controller parameters provide us a potential tool to optimize the parameters in the dynamical systems, which can be from electromagnetic, mechanical parts besides controllers, if such parameters can be augmented under one single “composite feedback gain matrix”. This is named as “integrated mechatronics design”, which allows partially reconfigure the system with exchanging parts and retuning the controller parameters during production. However, unlike the problem of pure controller parameter synthesis, the formed “composite feedback gain matrix” is with the structure constraints, which cannot be solved by methods such as Riccati equation and linear matrix inequality. This talk would like to share some recent progress to solve this class of problems by extending the optimal control theory. First, the revisions of the optimal control theory on linear quadratic regulator, H_2 and H-Infinity control are given. And the limitations of the current controller synthesizing methods when dealing with the integrated mechanical design are given subsequently. Later, the parameter optimization method toward integrated mechatronics design is given in the case that the system has an accurate model. Eventually, such method is further extended to the case that the accurate model of the system is unavailable. The case studies are accomplished to illustrate the applicability of the developed method. Last by not least, the remarks on possible future works are given.

Eddy-Current Field Reconstruction and Control Based on Distributed-Parameter Models for Machine Perception and Stimulation

With many outstanding characters (such as great penetration, fast response, well-defined theory, and insensitivity to oil or other media), eddy current (EC) generated inside the electrically conductive objects with the presence of the timing-varying magnetic field has been widely used in the fields of nondestructive sensing and testing, manufacturing and biomedicine. EC not only has the ability to noninvasively measure/detect object properties (machine perception), but also works as an approach of non-contact energy transmission (electromagnetic stimulation). A new machine perception method based on EC effects to reconstruct physical fields (EC field, electrical-conductivity field and hidden geometrical features) of a nonferrous material commonly encountered in intelligent manufacturing using finite magnetic flux density (MFD) measurements will be introduced. The measurement models of physical fields based on the established distributed-parameter models using discrete MFD measurements are linearly established, reducing the physical field reconstruction to a linear inverse problem for solving using Tikhonov regularization method. Based on the distributed-parameter models of the EC system, a direct field-feedback method to control 3 dimensional (3D) unmeasurable EC fields/stimulation with multiple electromagnets (EMs) using the finite MFD measurements will also be introduced. This method provides a possible approach for the controls of other unmeasurable physical fields.

Biographies

Kun Bai received his B.S. degree from Zhejiang University, China in 2006 and earned his M. S. and Ph. D. degrees both from the Woodruff School of Mechanical Engineering at Georgia Institute of Technology, Atlanta, US in 2009 and 2012 respectively. Currently, he is Associate Professor with the State Key Laboratory of Digital Manufacturing Equipment and Technology and the School of Mechanical Science and Engineering at Huazhong University of Science and Technology, China. His research interests include smart actuators/sensors and their novel applications, where he has published a book and over 30 papers and also held over 10 patents from China and US. He received ASME DSCD Mechatronics TC Best Paper Award in 2019. He is Guest Editor of IEEE/ASME Trans. on Mechatronics and also Associate Editor for IEEE/ASME International Conference on Advanced Intelligent Mechatronics.
Shaohui Foong is an Associate Professor in the Engineering Product Development (EPD) pillar at the Singapore University of Technology and Design (SUTD) and Visiting Academician at the Changi General Hospital, Singapore. He received his B.S., M.S. and Ph.D. degrees in Mechanical Engineering from the George W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, USA. He is currently the principal investigator for the Aerial Innovation Research (AIR) Laboratory @ SUTD and actively pursues research in unmanned systems, robotics as well as medical devices. One of his ongoing projects is centred on developing nature inspired aerial crafts which adapts the dispersal mechanism of maple seeds to achieve efficient flight. His other research interests include system dynamics & control, nature-inspired robotics, magnetic localization, medical devices and design education & pedagogy.

Chun-Yeon Lin received the B.S. degree in mechanical engineering from National Central University, Taoyuan, Taiwan, in 2003; the M.S. degree in electrical control engineering from National Chiao-Tung University, Hsinchu, Taiwan, in 2005; the M.S. degree in mechanical engineering from Stanford University, Stanford, CA, USA, in 2011; and the Ph.D. degree in mechanical engineering from George W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA, USA, in 2017. Currently, he is an assistant professor in the Department of Mechanical Engineering, National Taiwan University. His current research interests include mechatronics, physical field modelling, and electromagnetic system.

Silu Chen received the B.Eng. and the Ph.D. degrees in Electrical Engineering from the National University of Singapore (NUS), in 2005 and 2010 respectively. From 2010 to 2011, he was with the Manufacturing Integration Technology Ltd, a Singapore-based semiconductor machine designer, as a senior engineer on motion control. From 2011 to 2017, he was a scientist in the Mechatronics group, Singapore Institute of Manufacturing Technology (SIMTech), Agency for Science, Technology and Research (A*STAR). During this period, he also acted as co-PI of the SIMTech-NUS Joint Lab on Precision Motion Systems, adjunct assistant professor of NUS, and PhD co-advisor for A*STAR Graduate School. Since 2017, he has been with the Ningbo Institute of Materials Technology and Engineering, Chinese Academy of Sciences, as a professor. His current research interests include design and optimization of high-speed motion control systems, and beyond-rigid-body control for compliant light-weight systems. He has published more than 80 technical papers, co-author one monograph on precision motion control and industrial automations. He is currently serving as Associate Editor of IEEE International Conference on Advanced Intelligent Mechatronics.

Min Li received the B.S. and M.S. degrees in mechanical engineering from the Huazhong University of Science and Technology, Wuhan, China, in 2008 and 2011, respectively, and the Ph.D. degree in mechanical engineering from Georgia Institute of Technology, Atlanta, GA, USA in 2017. He is currently an Assistant Professor with the Department of Mechanical and Civil Engineering, Minnesota State University, Mankato, MN 56001 USA. His research interests include system dynamics/control, automation, and mechatronics.
Workshop II

**Agile Robotics for Industrial Automation Competition**

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<td>William Harrison, National Institute of Standards and Technology</td>
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<td>Craig Schlenoff, National Institute of Standards and Technology</td>
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**Time**

9 AM – 12:30 PM and 1:30 – 5 PM (US EDT)

**Location**

Room W2


**Description**

The Agile Robotics for Industrial Automation Competition (ARIAC) is designed to test the agility of industrial robot systems, making them more productive and autonomous, while requiring less time from shop floor workers. The goal is to promote automatic failure identification and recovery, automated planning to minimize up-front robot programming time, and ease of swapping out robots of different manufacturers without massive reprogramming. Come learn more about this competition and how to get involved in future iterations. Hear winning approaches from the top finishing teams and help guide the direction of the competition as it moves forward.

**Invited Talks**

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**Abstracts**

**ARIAC Overview**

An overview of the work that NIST does in the field of Agility and how this has led to the ARIAC Competition.

**ARIAC Environment**

An overview of how the environment for the ARIAC Competition has been designed, the reasoning behind the design choices, and some of the back-end details of the competition.
ARIAC Metrics

A presentation on the what metrics were used and how they were determined for this year’s ARIAC competition, including discussion of what things have changed or are planned to change in future years.

Team Approach Talk I

A presentation on how the team decided to approach the problems of this year’s ARIAC competition and unique methods of overcoming the new challenges.

Team Approach Talk II

A presentation on how the team decided to approach the problems of this year’s ARIAC competition and unique methods of overcoming the new challenges.

Team Approach Talk III

A presentation on how the team decided to approach the problems of this year’s ARIAC competition and unique methods of overcoming the new challenges.

Industry Representative Talk I

A presentation on the needs and thoughts of the manufacturing industry, how the competition is doing in terms of meeting those needs and helping shape the future direction of the competition.

Industry Representative Talk II

A presentation on the needs and thoughts of the manufacturing industry through the ROS-Industrial community, how the competition is doing in terms of meeting those needs, and helping shape the future direction of the competition.
Biographies

Craig Schlenoff is the Group Leader of the Cognition and Collaboration Systems Group, the Associate Program Manager of the Measurement Science for Manufacturing Robotics Program, and the Project Leader of the Agility Performance of Robotic Systems project in the Intelligent Systems Division at the National Institute of Standards and Technology. His research interests include knowledge representation/ontologies, intention recognition, and performance evaluation of autonomous systems and industrial robotics. He has led multiple million-dollar projects addressing performance evaluation of advanced military technologies and agility performance of manufacturing robotic systems. He has published over 150 journal and conference papers, guest edited three journals, guest edited three books, and written four book chapters. He is currently the Associate Vice President for Standardization in the IEEE Robotics and Automation Society and the co-chair of the IEEE Robot Task Representation Working Group, was previously the chair of the IEEE Ontology for Robotics and Automation Working Group and has served as the Program Manager for the Process Engineering Program at NIST and the Director of Ontologies at VerticalNet. He also teaches two courses at the University of Maryland, College Park: “Calculus” and “Building a Manufacturing Robot Software System.” He received his Bachelor’s degree from the University of Maryland, his Master’s degree from Rensselaer Polytechnic Institute, and his PhD from the University of Burgundy (France).

William Harrison is a mechanical research engineer in the Department of Commerce’s National Institute of Standards and Technology (NIST). Harrison’s specialty within the project is virtual fusion, which is the mix of simulated and real components for process validation and training. His interests include virtual reality, game engines, augmented reality, and CG modeling. He received his bachelor’s degree from the University of Michigan, his master’s from the University of Florida, and his PhD from the University of Michigan.

Anthony Downs is a Mechanical Engineer at the National Institute of Standards and Technology, working in the Intelligent Systems Division. He is one of the designers of the Agile Robotics for Industrial Automation Competition (ARIAC) which is currently running its 4th year in 2020 and has served as one of the Judges for the ARIAC competition during the 2019 competition. He is the lead in the IEEE Standards Association (IEEE SA) Study Group on Robot Agility, which is currently in the process of becoming a Working Group under the Robotics and Automation Society (IEEE RAS) for developing standards and test metrics for Robot Agility. He is also part of the IEEE SA Robot Task Representation Working Group which is working to develop a representation of robot tasks that is independent of the nature of the task being performed. He has received awards for his efforts contributing to the testing of robots and technology, including the 2011 TARDEC Director’s Coin award for the NIST Efforts in support of the Multi Autonomous Ground-robotic International Challenge (MAGIC), the “Outstanding Information Technology Achievement in Government” from the Government Computer News (GCN) and a NIST/Department of Commerce Gold Medal for the NIST Efforts in developing and performing tests and evaluations for the DARPA Transformative Applications Project, and the 2014 NIST Edward Bennett Rosa Award for “Outstanding Achievement in or contributions to the development of meaningful and significant engineering, scientific or documentary standards either within NIST or in cooperation with other government agencies or private groups” for the work on the DHS/NIST/ASTM Standard Test Methods for Response Robots Project.

Attila Vidacs received the MSc and PhD degrees from the Budapest University of Technology and Economics (BME) at the Faculty of Electrical Engineering and Informatics, in 1996 and 2000, respectively. His research interests are in the field of cloud robotics, cooperative and modular robot systems, IoT communication technologies, ad-hoc and wireless networking. Currently he is leading the Cloud Robotics Group within HSN Lab. He was involved as a researcher in many national and international research project (including EU H2020 5G-SMART, EU FP5 IST-MIND, IST-INTERMON; FP6 IST-MOME, IST-MUSE, E-NEXT; FP7 EARTH, and acted as a Management Committee Member of COST Actions 295 and IC-0806). He published more than 100 conference and journal papers in various scientific research fora. He was the deputy head of BME-TMIT (2013- 2016). He was the head of the High Speed Networks Lab (HSN Lab), a research group of more
than 20 researchers and 40 PhD students at BME (2013-2018). Between 2000 and 2006 he worked as a member of Research Group for Informatics and Electronics of the Hungarian Academy of Sciences. He worked as a visiting researcher at the University of Technology, Computer Architecture and Digital Technique Lab, Delft, The Netherlands; at the Research and Development Center of the Nippon Telegraph and Telephone Corp., Tokyo; and at the Lab of Telecommunications Technology of Helsinki University of Technology, Espoo, Finland.

**Siwei Feng** is a second year Ph.D. student studying computer science at Rutgers, supervised by Prof. Jingjin Yu with a research focus on multi-robot systems.

**Philip Freeman** is a Senior Technical Fellow in Boeing Research and Technology (BR&T), currently focused on Advanced Production Systems, Assembly Automation, & Precision Robotics. As a Senior Technical Fellow in the area of Materials and Manufacturing Technology, Dr. Freeman has expertise in robotics, automation, and control. He works from Boeing’s Research and Technology Center in South Carolina. From 2012 to 2014, Dr. Freeman worked with BR&T South Carolina on 787 production support, helping the program meet production ramp up rate targets. Prior to that, he worked in the Assembly and Integration Technology team in St. Louis where he helped implement many of the automated drilling systems on the F/A-18 and F-15. Previously, he worked as Boeing’s liaison to the Advanced Manufacturing Research Centre in Sheffield, UK where he led the Centre’s development of an automated assembly research team, now the AMRC’s Integrated Manufacturing Group (IMG). Since joining Boeing in 1998, Dr. Freeman’s research work has been primarily focused on improving the accuracy of precision automated drilling and milling systems through accurate kinematics modeling and the use of robust machine vision. He holds over 30 patents covering a range of manufacturing technologies, and is an author on several publications in machine tool volumetric accuracy and machine vision for inspection. Currently, his research focus is in the area of automatic task and path planning for industrial automation. Dr. Freeman is a member of American Society of Mechanical Engineers (ASME) where he is on the Board of Strategic Initiatives, serves as the vice chairperson for ASME B5.TC52 standards committee on machine tool performance, and is a contributing member to the Subcommittee on Robotic Arms (Manipulators). He is also a member of the Institute of Electrical and Electronic Engineers (IEEE) where he previously served on the industrial advisory board for the Robotics and Automation Society (RAS). Dr. Freeman earned his D.Sc. in System Science and Mathematics (2012), his M.S. in Mechanical Engineering (2003), and his B.S. in Mechanical Engineering (1997) all from Washington University in St. Louis.

**Matthew Robinson** is the Program Manager for the ROS-Industrial Consortium Americas. He is bringing his energy and passion to an exciting opportunity to make an impact and contribute to the advanced capabilities and performance of ROS-Industrial through the leadership of the ROS-Industrial Consortium, leveraging experience base to seek to bridge gap from strictly to technical development to sustainable, replicable, value realizing solutions on factory floors. During his time at Caterpillar, he led a research team in manufacturing automation applications, managed programs and projects to deliver novel validated solutions to solve difficult challenges in the areas of fabrication, planning, and process/value chain optimization. He developed initial quality system for new fabrication facility for aftertreatment components utilizing APQP methodology, developed welding technologies for the welding of aftertreatment components, procured manufacturing equipment for new fabrication facility. He developed automated inspection system and requirements for heavy fabs, led development of manufacturing line optimization tools for fabrication facilities, consulted on new manufacturing technologies as part of NPI process and incorporated lean methods for the fabrications of these new products. He led efforts regarding automation technology research and implementation.
Workshop III

Challenges and Opportunities of Soft Robotics: Research, Applications, and Education

Organizers
Hao Su, City University of New York
Kevin Chen, Massachusetts Institute of Technology
Antonio Di Lallo, City University of New York

Time
9 AM – 12:30 PM (US EDT)

Location
Room W3
https://haosu-robotics.github.io/aim-soft-robot-workshop.html

Description

During the past few years, advancement in material sciences, flexible electronics, sensors/actuators, and computation/algorithms creates new opportunities for research and development of soft robots. The paradigm shift from rigid contact towards soft interaction enables not only a safer physical human-robot interaction but also new forms of robots. The workshop brings experts in the field together to present state of the artwork and discuss the trend of enabling technologies for soft robots that are either biomimetic or for real-world applications. The workshop will also cover how to leverage soft robots to lower the barrier for STEM education.

Invited Talks

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Abstracts

Instability-driven soft robots

Fluidic soft actuators are enlarging the robotics toolbox by providing flexible elements that can display highly complex deformations. Although these actuators are adaptable and inherently safe, their actuation speed is typically slow because the influx of fluid is limited by viscous forces. To overcome this limitation and realize soft actuators capable of rapid movements, we focus on spherical caps that exhibit isochoric snapping when pressurized under volume-controlled
conditions. First, we note that this snap-through instability leads to both a sudden release of energy and a fast cap displacement. Inspired by these findings, we investigate the response of actuators that comprise such spherical caps as building blocks and observe the same isochoric snapping mechanism upon inflation. Last, we demonstrate that this instability can be exploited to make these actuators jump even when inflated at a slow rate. Our study provides the foundation for the design of an emerging class of fluidic soft devices that can convert a slow input signal into a fast output deformation.

Magnetic Soft Robots

While human tissues are mostly soft, wet and bioactive; machines are commonly hard, dry and biologically inert. Bridging human-machine interfaces is of imminent importance in addressing grand challenges in health, security, sustainability and joy of living faced by our society in the 21st century. However, designing human-machine interfaces is extremely challenging, due to the fundamentally contradictory properties of human and machine. In this talk, we will highlight MIT SAMs Lab’s recent development of soft robots that can potentially perform various tasks inside human body. The soft robots are constructed by 3D printing of a new biocompatible magneto-active polymer into various structures. Our approach is based on direct ink writing of an elastomer composite containing ferromagnetic microparticles. By applying a magnetic field on the dispensing nozzle while printing, we make the particles reoriented along the applied field to impart patterned magnetic polarity to printed filaments. This method allows us to theoretically and experimentally program ferromagnetic domains in complex 3D-printed soft robots, enabling a set of unprecedented functions including crawling, jumping, grasping and releasing objects, and transforming among various 3D shapes controlled by applied magnetic fields. The actuation speed and power density of our 3D-printed soft robots with programmed ferromagnetic domains are orders of magnitude greater than existing 3D-printed active materials and structures. We will demonstrate a set of clinically relevant applications uniquely enabled by the 3D-printed magneto-active soft robots.

Mathematical Modeling of Soft Robots

Soft and continuum robots have gained remarkable popularity in recent years. A multitude of interesting designs that have inflatable chambers and/or actuated fibers can cause soft robots to contort in a wide variety of ways. Moreover, they have the ability to passively conform to objects for grasping and manipulation with limited needs for active force control. This makes them ideal for physical human-robot interaction tasks, such as those required in assistive and elderscare applications. Despite recent clever designs, the methods used to analyze and predict the performance of soft robots often rely heavily on black-box finite-element (FEM) solvers. In other words, the soft robot is divided up into small voxels, and ancient laws of continuum mechanics are applied, as in engineering practice. Or, in the case of slender continuum filaments that have become popular in medical robotics, backbone curve ideas are adopted from the pre-existing literature on hyper-redundant robots (and sometimes re-branded as something completely new). In this talk, an extension of the ‘modal approach’ to hyper-redundant robot kinematics introduced in the speaker’s PhD dissertation from almost 30 years ago is combined with his previous work on parameterized closed-form deformations which locally preserve volume. This provides a potential alternative to FEM wherein the essential degrees of freedom are captured for incorporation in real-time control. Local volume preservation is to 3D soft robots what arclength is to 1D continuum filaments. Capturing this constraint in motion primitives provides a way to describe a rich set of deformations to model soft robots, as described in this talk.

Untethered high performance soft robots for human augmentation

Wearable robots for physical collaboration with humans are the new frontier of robotics, but they are typically bulky, obtrusive, and lack intelligence. Soft robots hold great potential to provide a conformal and unobtrusive interface to humans. However, soft robots are generally slow, suffer from low forces, and tethered to energy sources. To overcome those challenges, we develop high-torque density actuators to enable untethered soft robots with high force and high bandwidth for physical human-robot interaction. In addition, we are studying controllers for a variety of versatile wearable soft robots we have developed to augment human performance for able-bodied individuals and enhance mobility for
people with lower-limb impairments, including children with cerebral palsy and people with musculoskeletal disorders. We envision our soft robots with learning-based controllers will enable a paradigm shift of wearable robots from lab-bounded rehabilitation machines to ubiquitous personal robots for workplace injury prevention, pediatric and elderly rehabilitation, and home care.

**Micro-aerial Robots Powered by Soft Artificial Muscles**

Flying insects capable of navigating in highly cluttered natural environments can withstand inflight collisions because of the combination of their low inertia and the resilience of their wings, exoskeletons, and muscles. Current insect-scale (<10 cm, <5 g) aerial robots use rigid microscale actuators, which are typically fragile under external impact. Towards improving collision robustness of micro-aerial robots, we develop the first heavier-than-air aerial robots powered by soft artificial muscles that demonstrate open-loop, passively stable ascending flight as well as closed-loop, hovering flight. First, we design and fabricate lightweight (0.1 g), power-dense (600 W/kg), and high bandwidth (500 Hz) dielectric elastomer actuators (DEA) to drive the robots. Second, we increase actuator output mechanical power and improve its control authority by addressing challenges unique to soft actuators, such as nonlinear transduction and dynamic buckling. Third, we demonstrate our robot can both achieve controlled hovering flight and passive inflight collision recovery. Our work demonstrates how soft actuators can achieve sufficient power density and bandwidth to enable controlled flight, illustrating the vast potential of developing next-generation agile soft robots.

**Research and Education at the Convergence of Frontier Technologies**

In this talk, I will lay out the evolution of research and education activities in MCRL. Slightly over two decades ago, I began by developing a hands-on control-engineering program that slowly transformed into research and education activities focused on mechatronics. A decade ago, with the arrival of smart mobile devices (smartphones and tablets), MCRL focused its efforts on mechatronics and robotics with applications to natural and intuitive human-machine interaction as well as health and wellness. More recently, having observed the rapid progress in several emerging technologies and their potential for broad societal impact, MCRL has transitioned its activities to explore and perform education and research activities at the convergence of robotics, artificial intelligence, augmented reality/virtual reality, and blockchain technologies. In this talk, in addition to sharing an overview of our education activities, I will showcase examples of our research products.

**Evolving the Physical Structure of Compliant, Soft, and Biological Robots**

In the vast majority of robotics projects (including soft robotics), it is assumed that the physical structure of the robot is designed manually or, at best, parameters of a manually-defined structure are optimized. In this talk I will survey our attempts to automate the design of soft robots from the ground up, and highlight the particular challenges and opportunities of doing so. In particular, I will describe how searching over ‘morphospace’ -- the space of all possible designs -- can have gradients that can be followed toward designs that increasingly facilitate control policy optimization, or improve simulation to reality transfer. I will draw examples from our recent work with flapping wings for ornithopters, voxel-based soft robots, and biological machines created using frog embryo cells.

**Programming Shape Shifting and Locomotion through Anisotropy**

Conventional robots are rigid. Although robust, they are often heavy, bulky, tethered and non-adaptive to environmental changes. Soft robots are light-weight, compliant, and adaptive, and can achieve multi-degrees of freedom. However, their softness makes it difficult to control the shape change and locomotion, or lift heavy weights. To precisely and locally
control the shapes and agile locomotion with considerable strains, we create thin films and filaments from liquid crystal elastomers (LCEs) and their composites. Through designs of geometric surface patterns, e.g. microchannels, we program the orientational elasticity in LCEs to direct folding of the 2D sheets into 3D shapes, which can be triggered by heat, light, and electric field. We then fabricate tendon-like filaments as high strength, dual-adaptive actuators in soft robotic applications, as well as programmable gaits to achieve different modes of locomotion.

**Bio-inspired Vine Robots and A Promising New Application**

Natural systems are incredibly robust, adaptable, and capable of handling uncertainty in their environments. These traits are desirable but challenging to realize in engineered robotic systems. I will discuss efforts to learn from nature, specifically vines and other tip-extending organisms, to create a robust method of navigating constrained environments. I will introduce the underlying principles found in this modality of movement, and how they can be translated to an engineered system. While this work began as an effort to address the application area of search and rescue, we have since found potential impact for another, very different problem, for which I will present preliminary results.

**Biographies**

**Katia Bertoldi** is the William and Ami Kuan Danoff Professor of Applied Mechanics at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS). Katia’s research contributes to the design of materials with a carefully designed meso-structure that leads to novel effective behavior at the macroscale. She investigates both mechanical and acoustic properties of such structured materials, with a particular focus on harnessing instabilities and strong geometric non-linearities to generate new modes of functionality. Since the properties of the designed architected materials are primarily governed by the geometry of the structure (as opposed to constitutive ingredients at the material level), the principles she discovers are universal and can be applied to systems over a wide range of length scales.

**Xuanhe Zhao** is a professor at MIT. The mission of Zhao Lab is to advance science and technology on the interfaces between humans and machines for addressing grand societal challenges in health and sustainability with integrated expertise in mechanics, materials and biotechnology. A major focus of Zhao Lab's current research is the study and development of soft materials and devices for translational medicine and water treatment. For example, Zhao Lab's invention of the hydrogel-elastomer tough hybrid is used in tissue phantoms for training doctors and researchers in medical imaging all over US. Dr. Zhao is the recipient of the NSF CAREER Award, ONR Young Investigator Award, SES Young Investigator Medal, ASME Hughes Young Investigator Award, Adhesion Society's Young Scientist Award, Materials Today Rising Star Award, and Web of Science Highly Cited Researcher. He held the Hunt Faculty Scholar at Duke University, and the d’Arbeloff Career Development Chair and Noyce Career Development Professorship at MIT.

**Gregory S. Chirikjian** is the head of the mechanical engineering department at the National University of Singapore. Chirikjian’s research interests include robotics, applications of group theory in a variety of engineering disciplines, and the mechanics of biological macromolecules. He is a 1993 National Science Foundation Young Investigator, a 1994 Presidential Faculty Fellow, and a 1996 recipient of the ASME Pi Tau Sigma Gold Medal. In 2008, Chirikjian became a fellow of the ASME, and in 2010, he became a fellow of the IEEE. From 2014-15, he served as a program director for the National Robotics Initiative, which included responsibilities in the Robust Intelligence cluster in the Information and Intelligent Systems Division of CISE at NSF. Chirikjian is the author of more than 250 journal and conference papers and the primary author of three books, including Engineering Applications of Noncommutative Harmonic Analysis (2001) and Stochastic
Hao Su is Irwin Zahn Endowed assistant professor in the Department of Mechanical Engineering at the City University of New York, City College and the Director of the Lab of Biomechatronics and Intelligent Robotics (BIRO). He was a postdoctoral research fellow at Harvard University and the Wyss Institute for Biologically Inspired Engineering. Prior to this role, he was a Research Scientist at Philips Research North America where he designed robots for lung and cardiac surgery. He obtained the Ph.D. degree on Surgical Robotics from the Department of Mechanical Engineering at Worcester Polytechnic Institute. Dr. Su received NSF CAREER Award, Toyota Mobility Challenge Discover Award, the Best Medical Robotics Paper Runner-up Award in the IEEE International Conference on Robotics and Automation (ICRA) and Philips Innovation Transfer Award. He received the Advanced Simulation & Training Award from the Link Foundation and Dr. Richard Schlesinger Award from the American Society for Quality. He holds patents on surgical robotics and socially assistive robots.

Kevin Chen is an assistant professor in the Department of Electrical Engineering and Computer Science (EECS) at MIT. He received his PhD in Mechanical Engineering at Harvard University under the supervision of Professor Robert J. Wood. He is a recipient of the best student paper award at the International Conference on Intelligent Robots and Systems (IROS) 2015, a Harvard Teaching Excellence Award, and he was named to the “Forbes 30 Under 30” list in the category of Science. His works have been published in top journals including Nature, Science Robotics, Nature Communications, and the Journal of Fluid Mechanics.

Vikram Kapila is a Professor of Mechanical and Aerospace Engineering at the NYU Tandon School of Engineering, where he directs a Mechatronics, Controls, and Robotics Laboratory; a Research Experience for Teachers Site in Mechatronics and Entrepreneurship; a DR K-12 and an ITEST STEM education research project; all funded by NSF. He has held visiting positions with the Air Force Research Laboratories in Dayton, OH. His research interests are focused on the convergence of frontier technologies (robotics, artificial intelligence, augmented/virtual reality, and blockchain) and STEM education. He is an author or co-author of more than 240 peer-reviewed scholarly publications, including books, book chapters, journal papers, and conference articles. He is a named inventor on two awarded patents. He has received five teaching awards and a leadership award, all at NYU Tandon. Moreover, he is a recipient of 2014-2015 University Distinguished Teaching Award at NYU. He has mentored more than 50 graduate researchers and more than 60 undergraduate researchers. In addition, he has conducted significant K-12 education, training, mentoring, and outreach activities to integrate engineering concepts in science classrooms and labs of dozens of New York City public schools.

Josh Bongard is the Veinott Professor of Computer Science at the University of Vermont and director of the Morphology, Evolution & Cognition Laboratory. His work involves automated design and manufacture of soft-, evolved-, and crowdsourced robots, as well as computer-designed organisms. A PECASE, TR35, and Microsoft New Faculty Fellow award recipient, he has received funding from NSF, NASA, DARPA, ARO and the Sloan Foundation. He is the author of the book How The Body Shapes the Way we Think, the instructor of a reddit-based evolutionary robotics MOOC, and director of the robotics outreach program Twitch Plays Robotics.

Elliot Hawkes is an assistant professor in the Department of Mechanical Engineering at University of California, Santa Barbara. Elliot Hawkes’s research focuses on bringing together design, mechanics, and non-traditional materials to advance the vision of robust, adaptable, human-safe robots that can thrive in the uncertain, unstructured world. Current projects involve bio-inspired microstructured adhesive materials, non-linear compliant mechanisms, high-power soft actuators, soft exoskeletons, and growing robots.
**Shu Yang** is a Professor in the Departments of Materials Science & Engineering, and Chemical & Biomolecular Engineering at University of Pennsylvania (Penn). Her group is interested in synthesis, fabrication, and assembly of polymers, liquid crystals, and colloids; investigation of the dynamic tuning of their sizes, shape and assembled structures, and use geometry to create highly flexible, super-conformable, and shape changing materials. Yang received her B.S. degree from Fudan University in 1992, and Ph. D. degree from Cornell University in 1999. She worked at Bell Laboratories, Lucent Technologies as a Member of Technical Staff before joining Penn in 2004. She received George H. Heilmeier Faculty Award for Excellence in Research from Penn Engineering (2015-2016). She is Fellow of Division of Soft Matter (DSOFT) from American Physical Society (APS), Division of Polymeric Materials: Science and Engineering from American Chemical Society (ACS) (2018), Royal Chemical Society (2017), and National Academy of Inventors (2014).
Workshop IV

Flexible Mechatronics for Robotics

Organizers
Jiajie Guo, Huazhong University of Science and Technology
Chao-Chieh Lan, National Cheng Kung University
Qining Wang, Peking University
Guimin Chen, Xi’an Jiaotong University

Time
9 AM – 12:30 PM (US EDT)

Location
Room W4
http://english.mse.hust.edu.cn/info/1006/2325.htm

Description

Flexible mechatronics have been critical and necessary to smart robots in unstructured environments under complicated states for they are effective in addressing the needs for adaptability to nonlinear deformations and robustness to harsh conditions. As a combination of compliant structures and stretchable electronics, flexible mechatronics has the advantages of light weights, compact sizes, zero backlashes, quick response and high energy efficiency, thus have wide applications such as human-motion sensing, health inspection, bio-inspired actuation, process state monitoring, high precision positioning/transmission, intelligent fixation and so on. With the emerging applications to robotics, this workshop provides an opportunity to highlight the role of flexible mechatronics in the most active research areas in recent years, and offers a platform for education, communication and discussion for the new developments on modeling theories, design methods, fabrication techniques, control principles and illustrative applications in the field.

As a flagship conference focusing on mechatronics and intelligent systems, the goal of IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM) remains to bring together an international community of experts to discuss the state-of-the-art, new research results, perspectives of future developments, and innovative applications relevant to mechatronics, robotics, automation, industrial electronics, and related areas. More details about the conference are available on http://aim2020.org/.

Invited Talks

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<td>Distributed field sensing for human-centered robotics</td>
<td>Jiajie Guo</td>
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<td>Compliant Motion Control of Stepper Motors Based on Phase Current Feedback</td>
<td>Chao-Chieh Lan</td>
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<td>Modeling large deflections in compliant mechanisms and continuum robots</td>
<td>Guimin Chen</td>
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<td>Human-Centered Wearable Robotics: From Land to Underwater Applications</td>
<td>Qining Wang</td>
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Abstracts

Distributed field sensing for human-centered robotics

Soft robots and human musculoskeletal systems are featured with continuous nonlinear deformations. However, it is a challenge to capture distributed dynamics with typical sensing techniques due to the limitations of rigid components and nodal measurements. This talk presents recent developments on distributed field sensing for soft robots and compliant musculoskeletal structures, where the unified reconstruction method is introduced with highlights of physics-based modeling, flexible mechatronics design, and wearable device fabrication. Its application to human-centered robotics is illustrated with several examples, including articular geometry sensing with the wearable compliant mechanism, force/motion sensing for the compliant robotic hand, and the flexible curvature sensor for amphibious gait measurements.

Compliant Motion Control of Stepper Motors Based on Phase Current Feedback

Actuators that can produce controllable compliant output motion are suitable for robots that need to interact safely with human or the environment. To obtain the accurate output torque required to control the compliant motion, existing robotic actuators use one or more sensors to measure the deformation of a stiff or compliant element between the actuator and the output. The complexity of sensors and limited bandwidth and stability of using the deformable element are the current challenges. This talk investigates a compliant motion control method of actuators based on motor current feedback only. Stepper motors are used because of their wide availability and high reliability. They also have much higher torque-to-weight ratio and torque-to-rotor-inertia ratio than other DC motors. Torque and impedance controllers based on stepper motor phase current feedback are developed. Forward and inverse torque/impedance tracking control experiments will be provided to show the advantages of the current-controlled stepper motor. It is expected that the new control method can offer a better actuator selection when cost, stability, and bandwidth of complaint actuators are the major concerns.

Modeling large deflections in compliant mechanisms and continuum robots

After reviewing the fundamental beam theories, this tutorial will discuss major challenges in modeling nonlinear deflections in compliant mechanisms, recently developed methods and their use for kinetostatic modeling of compliant mechanisms, both from the vectorial and the strain energy perspectives. The talk is scheduled as follows:

(1) Fundamentals
   Topic 1: Beam theories
   Topic 2: Different methods

(2) Vectorial Modeling
   Topic 1: Method
   Topic 2: Examples

(3) Energy-Based Modeling
   Topic 1: Method
   Topic 2: Examples

Human-Centered Wearable Robotics: From Land to Underwater Applications

This talk will show recent progress on wearable robotics, especially the new area of underwater applications. To date, all the exoskeletons have been studied to assist human motions on land. However, regardless of the exoskeletons being rigid or soft, an exoskeleton for underwater motion assistance has not been realized thus far. This talk will discuss the challenges of using exoskeletons for underwater applications. And recent breakthrough of an underwater soft exoskeleton from my lab will be introduced in detail. Three competitive swimmers participated the experiments to evaluate the proposed soft exoskeleton. Compared with breaststroke without assistance, the peak of surface electromyography in the sweep phase with the exoskeleton assistance decreased by 49.13% (gastrocnemius) and 74.51% (soleus) on an average.
Biographies

Jiajie Guo received his Ph.D. degree in mechanical engineering from Georgia Institute of Technology, Atlanta, GA, USA, in 2011, and B.S. degree in theoretical and applied mechanics, Peking University, Beijing, China, in 2006. He is currently a Professor with the State Key Laboratory of Digital Manufacturing Equipment and Technology, and the School of Mechanical Science and Engineering, Huazhong University of Science and Technology, Wuhan, China. His research interests include flexible mechatronics, human-centered robotics, and system dynamics/control. He co-authored the book “Flexonics for Manufacturing and Robotics: modeling, design and analysis methods” by Springer Nature, and received the best paper award for IEEE/ASME Trans. on Mechatronics (2015). He recently serves on the editorial boards for two international journals, Current Chinese Engineering Science, Current Mechanics and Advanced Materials, and IEEE/ASME Int. Conf. Advanced Intelligent Mechatronics (AIM).

Chao-Chieh Lan is currently a professor in the Department of Mechanical Engineering at National Cheng Kung University, Taiwan. He is currently interested in compliant actuators, robotics, multi-body dynamics, and rehabilitation devices.

Guimin Chen is a full professor of Xi’an Jiaotong University. He was a visiting professor Brigham Young University (BYU CMR Lab) from December 2016 to August 2017 and from October 2007 to October 2008. He serves as an Associate Editor of ASME Journal of Mechanisms and Robotics and a Topical Editor of Mechanical Sciences (IFTOMM affiliated). He is a recipient of ASME Compliant Mechanisms Award. His research interests include compliant mechanisms and their applications.

Qining Wang received his Ph.D. degree in Dynamics and Control from Peking University in 2009. He serves as the Vice-Dean of the College of Engineering in Peking University, China. He has authored/coauthored over 170 scientific papers in international journals and refereed conference proceedings. His research interests include bio-inspired robots and rehabilitation robotics. He serves as an Advisor of the IEEE-RAS Technical Committee on Wearable Robotics. He was an Associate Editor for the IEEE Robotics and Automation Magazine from 2016 to 2018. He has been a Technical Editor for the IEEE/ASME Transactions on Mechatronics since 2017, and an Associate Editor for the IEEE Transactions on Medical Robotics and Bionics since 2018.
**Workshop V**

**Supernumerary Robotic Devices**

**Organizers**
Guy Hoffman, Cornell University  
Ryder C. Winck, Rose-Hulman Institute of Technology  
Vighnesh Vatsal, Cornell University

**Time**  
9 AM – 12:30 PM and 1:30 – 5 PM (US EDT)

**Location**  
Room W5  
https://aim2020srd.wixsite.com/aim2020srd

**Description**

The field of wearable robotics focuses today mostly on prostheses and exoskeletons. These devices are designed to either replace lost human capabilities or to enhance existing ones. In fact, both prostheses and exoskeletons have reached considerable maturity in terms of research and commercialization efforts over the past decades. Spurred on by recent advances in high-performance actuators and microcontrollers, as well as by increasingly inexpensive computational power, we are witnessing the advent of another class of wearable robots: supernumerary robotic (SR) devices. SR devices aim to add capacities to a human body beyond the naturally occurring and are often modeled as additional upper limbs. While SR device design is largely inspired by prostheses and exoskeletons, research into other facets of this technology beyond design, such as interaction, control systems, biomechanics, and human-robot collaboration, is still in a nascent stage. As a result, the community of SR device researchers is fairly small and insular. This workshop would provide a common forum for existing researchers who are working on aspects of SR devices to communicate their latest advances. It would also assist interested students and researchers working on other areas of robotics in getting involved with SR device research to initiate new projects.

**Invited Talks**

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<td><strong>Handheld Robots: Bridging the gap between fully external and wearable robots</strong></td>
<td>Walterio Mayol-Cuevas</td>
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<td>2</td>
<td><strong>Playing the piano with 11 fingers – the neurobehavioural constraints of human robot augmentation</strong></td>
<td>A. Aldo Faisal</td>
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<td>3</td>
<td><strong>Virtual Cyborgs: Freedom from Body Limitations</strong></td>
<td>Masahiko Inami</td>
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<td>4</td>
<td><strong>TBD</strong></td>
<td>Domenico Prattichizzo</td>
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<td>5</td>
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<td>Monica Malvezzi</td>
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<td>7</td>
<td><strong>Supernumerary robotic manipulation for Laparoscopic surgery, envisioned scenarios and results</strong></td>
<td>Mohamed Bouri</td>
</tr>
</tbody>
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Abstracts

Handheld Robots: Bridging the gap between fully external and wearable robots

In this talk, we will discuss our past and recent work on the development of handheld robots. A Handheld robot is a person-oriented robot that shares properties of a handheld tool while being enhanced with autonomous motion as well as the ability to process task-relevant information and user signals. The application possibilities include helping inexperienced users to perform power tool-type tasks without much task knowledge and with limited training on the tool usage. These robots exploit the Moravec paradox by combining the strengths of human users such as innate obstacle avoidance and navigation skills, with precise motion and memory enhancement by robotic devices. In our recent work we have explored issues of the way to predict user intention from minimal user input such as gaze detection and motion, and issues of conflict of interests between user and robot. We have built prototypes of handheld robots and conducted various pilot studies on the effects of intention prediction, robot rebellion and tele-operation on simulated copy-block and maintenance tasks. We believe handheld robots bridge the gap that currently exists between fully independent robots for which full autonomy is the goal, and wearable or supernumerary robots where the robot is tightly coupled with the user. With handheld robots, we hope to tap into the millions of years that humans have used handheld tools but now with the enhancement possibilities that Robotics can offer. http://handheldrobotics.org/

Biographies

Walterio Mayol-Cuevas is a Professor in Robotics, Computer Vision and Mobile Systems at the University of Bristol. His research centers around three related areas: robotics, wearable computing and computer vision.

A. Aldo Faisal is Reader in Neurotechnology (US equivalent: Associate Professor, tenured) jointly at the Dept. of Bioengineering and the Dept. of Computing at Imperial College London, where he leads the Brain & Behaviour Lab. Aldo is also Director of the Behaviour Analytics Lab at the Data Science Institute. He is also Associate Investigator at the MRC London Institute of Medical Sciences and is affiliated faculty at the Gatsby Computational Neuroscience Unit (University College London).

Masahiko Inami is a Professor at the Research Center for Advanced Science and Technology at the University of Tokyo.

Domenico Prattichizzo is a Full Professor at the University of Siena. His research interests are in haptics, grasping, visual servoing, mobile robotics and geometric control.

Monica Malvezzi is an Associate Professor of Mechanics and Mechanism Theory at the Dipartimento di Ingegneria dell'Informazione e Scienze Matematiche of the University of Siena and she has been Visiting Scientist at Istituto Italiano di Tecnologia since 2015. Her main research interests are in mechanism theory, control of mechanical systems, robotics, vehicle localization, multibody dynamics, haptics, grasping and dexterous manipulation.
Hiroyasu Iwata is currently a Professor with the Department of Modern Mechanical Engineering, School of Creative Science and Engineering, Waseda University. His current research interests include advanced technology for construction machinery, robotics in medical care, rehabilitation assistive robot, and anthropomorphic dexterous hand and manipulator.

Mohamed Bouri is with Ecole Polytechnique Fédérale de Lausanne (EPFL, Switzerland). He graduated in Electrical Engineering in 1992 and obtained his PhD degree in 1997 in Industrial Automation at INSA LYON, France. He is the head of Rehabilitation and Assistive Robotics group at EPFL since 2012 and lecturer of Robotics and Industrial Robotics. His main focus concerns lower limb rehabilitation robotic devices and exoskeletons and is also active in surgical and industrial robotic applications (http://rehassist.epfl.ch)
Special Sessions

Virtual Session: Mechatronics for Infectious Diseases

Organizers
Hao Su, City University of New York, City College
Yan Gu, University of Massachusetts at Lowell
Jingang Yi, Rutgers University – New Brunswick

Video Presentation
https://www.youtube.com/playlist?list=PLZwpOtY5YJ61vS7YxiOEP8shJ9VMsjfO3

Description
The coronavirus pandemic has dramatically disrupted global healthcare, quality of life, and even everyone's lifestyle of daily livings. Mechatronics has the potential to play a critical role in mitigating this impact and reducing disease transmission through a wide variety of sensors, actuators, and robotics solutions, e.g., telerobots for remote operation in risky environments and tasks. However, there are a number of challenges to enable the rapid deployment of rugged robots for robust and intelligent operation in the fields. A panel of invited speakers who are experts in medical robots, disaster robots, wearable robots, and AI will present their research and perspective about the current status of mechatronics for infectious diseases, gaps, and potential solutions. This workshop aims to stimulate inspiration and collaboration through multidisciplinary approaches and perspectives to propose better solutions to combat different kinds of infectious diseases and get fully prepared for the next pandemic.

Website: https://haosu-robotics.github.io/aim-mechatronics-for-infectious-diseases.html

Virtual Session: Greater Boston Area Robotics and Mechatronics Research

Organizers
Hao Su, City University of New York, City College
Yan Gu, University of Massachusetts at Lowell

Video Presentation
https://www.youtube.com/playlist?list=PLR_R9tR1KqpkCD35q8nTOitVgJz1vQ8L

Description
Greater Boston is one of the world's leading centers for robotics and mechatronics. Over 200 institutions, companies, and research labs in the region are actively engaged in research, education, and technological development in the areas of robotics and mechatronics. While AIM 2020 was planned to be held in Boston but now moves to a virtual event due to COVID-19 pandemic, this special session aims to help expose the wide range of robotics and mechatronics related activities and facilities in Greater Boston to the conference attendees as well as a broader audience worldwide. In this special session, invited speakers from Greater Boston who are driving and promoting the transformative advancement of robotics and mechatronics will unfold to us the central role of the region in leading the world on various key fronts of education, research, and innovation.

Website: http://www.thetracelab.com/workshops.html
**Virtual Session: Interactive Labs for Distance & Blended Control Systems and Robotics Courses**

**Organizers**
Gemma Wang, Quanser  
Peter Martin, Quanser

**Video Presentation**
https://www.gotostage.com/channel/db95ad1de6694e7b9f1067cfeddb901c8/recording/4e8228e0e41c473bb04870551abbeee6/watch

**Description**
Distance learning is becoming an essential component of modern engineering education but moving a traditional engineering course online remains challenging. Based on our industry-leading hardware products for controls, robotics, and mechatronics, the Quanser Interactive Labs platform delivers credible, academically appropriate, and high-fidelity lab experiences through interactions with virtual hardware using a desktop or smart device. Subscriptions to content bundles are available to unlock a variety of experiences on Windows, macOS, iOS, and Android with no need for any institutional IT infrastructure to deploy the platform. In this webinar Peter Martin (Senior R&D Manager of Academic Applications at Quanser, Peter.Martin@quanser.com) will demonstrate and discuss the QLabs Controls, and QLabs Robotics content bundles that are the most flexible, engaging, modern approach to distance and blended learning for control systems and robotics.

**Website:** https://www.gotostage.com/channel/quanser-webinars

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**Meeting with the Editor-in-Chief of IEEE/ASME Transactions on Mechatronics**

**Organizers**
I-Ming Chen, Nanyang Technological University, Singapore

**Time**
July 7, 10:15 - 11:15 AM (US EDT)

**Zoom Link**
https://zoom.us/j/95054677567?pwd=QjV0TG40RXZoTVdUaVBrVjNIZUZKQT09

**Description**
The EiC of TMECH, Prof. I-Ming Chen will give a brief on the scope of TMECH, on advise how to write a good scientific paper as well as what TMECH is looking for. In the meantime, we will also introduce the newly established TMECH junior reviewer program to recruit potential reviewers for TMECH as part of the service to mechatronics community.
Plenary Talk I

Novel Methods for Modeling and Field-Reconstruction of Dynamic Systems with Application for Multi-task Sensing

Speaker  Kok-Meng Lee

Time  9:00 – 10:00 AM, July 7, 2020 (US EDT)

Location  Room T13

Abstract

Over the past four decades, mechatronics has grown in concert with rapid advancing 4C (computer, communication, control and consumer-product) technologies through several paradigm shifts that transform 4C from room-size mainframes to desktop microprocessors, then from palms to cloud. Nowadays, intelligent mechatronics plays increasingly important roles in many emerging growth areas where more and more smart real-time functions are expected in highly complex systems involving multi-physics in small footprints; traditional lumped-parameter approaches, tedious empirical models based on point measurements, and time-demanding finite-element methods are no longer adequate to meet new challenges in this data-rich paradigm. Motivated by the needs to equip complex distributed-parameter dynamic system (DPDS) with adequate machine perception to analyze data for decision making, this talk presents a unified distributed state-variable (DSV) method for modeling a DPDS in state-space representation and reconstructing its physical fields from data, and a general framework utilizing reconstructed fields to optimize the perceptions of the DPDS enabling it to execute multiple tasks in real time simultaneously. To help visualize, the methods are illustrated in the context of metal additive-manufacturing (AM) and post-AM machining of thin-wall components, where a multi-task sensing system detects defects while conducting geometrical and material-property measurements. DSV modeling, as a bridge linking machine perception as a data-driven tool to model-based control widely known in the mechatronics community, will find a spectrum of applications (including detection of abnormalities) as well as emerging innovation where physical fields can be exploited for real-time sensing and control.

Biography

Professor Kok-Meng Lee received his M.S. and Ph.D. degrees in mechanical engineering from Massachusetts Institute of Technology in 1982 and 1985, respectively. He has been with Georgia Institute of Technology since 1985. As a Professor of mechanical engineering, his research interests include system dynamics and control, machine vision, robotics, automation and mechatronics. Dr. Lee is founding Editor-in-Chief (EIC) for the Springer International Journal of Intelligent Robotics and Application (IJIRA). Prior to becoming IJIRA EIC, he served as EIC for the IEEE/ASME Transactions on Mechatronics (2008-2013). He co-founded the IEEE/ASME International Conference on Advanced Intelligent Mechatronics in 1997 and hosted its following edition (AIM1999) as General Chair in Atlanta, USA. He had also held representative positions in the IEEE Robotics and Automation Society; Associate Editor for IEEE Robotics and Automation Magazine (1994-1996) and IEEE Transactions on Robotics and Automation (1994-1998) and IEEE Transactions on Automation Science and Engineering (2003-2005). He served on the Executive Committee of ASME Dynamics Systems and Control Division (2013-2107, Chair 2016). He co-
authored four books on modeling and field-based approaches for design and control of electromagnetic actuators and flexonic systems, and has held several patents on machine vision systems, ball-joint-like spherical motors, and automated systems for transferring live objects. Dr. Lee is a Life Fellow of ASME and a Fellow of IEEE. Other recognition of his research contributions includes Presidential Young Investigator (PYI) Award, Sigma Xi Junior Faculty Award, International Hall of Fame New Technology Award, Woodruff Faculty Fellow, and Michael J. Rabins Leadership Award.
Plenary Talk II

Soft robotics: from bioinspiration to new mechatronic technologies for further robotics application scenarios

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<th>Cecilia Laschi</th>
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<tr>
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Abstract

Mechatronics and robotics have progressed rapidly and offered a variety of solid technologies for application in industry and beyond, ensuring proper response to a growing market. Such progress is expected to have an even higher impact in the near future, by making mechatronics and robotics pervade our daily life. Soft robotics has been contributing to this scenario in the latest years, with a perspective of rapid growth and high scientific and technological impact. Soft robotics contribution is providing robots with abilities that come from bioinspiration and build on technological challenges that feed the progress of this field. They range from insights on the use of soft and smart materials in robotics, to soft actuation and sensing technologies, modelling and control of soft robots, as well as system integration and power supply. Rethinking mechatronic components is giving life to soft robots that nicely complement the huge potential of robotics for becoming part of our lives, for responding to current societal challenges, and for contributing to economic growth.

Biography

Professor Cecilia Laschi is Full Professor at Scuola Superiore Sant'Anna in Pisa, Italy, in the BioRobotics Institute (part of the Department of Excellence in Robotics & AI), where she serves as Deputy Director. She graduated in Computer Science at the University of Pisa in 1993 and received the Ph.D. in Robotics from the University of Genoa in 1998. In 2001-2002 she was JSPS visiting researcher at Waseda University in Tokyo. Her research interests are in the field of soft robotics, a young research area that she pioneered and contributed to develop at international level, including its applications in marine robotics and in the biomedical field. She has been working in humanoid robotics and neurorobotics, at the merge of neuroscience and robotics. She is in the Editorial Boards of several international journals, including Science Robotics. She serves as reviewer for many journals, including Nature and Science, for the European Commission, including the ERC programme, and for many national research agencies. She is senior member of the IEEE, of the Engineering in Medicine and Biology Society (EMBS), and of the Robotics & Automation Society (RAS), where she serves as elected AdCom member and co-chairs the TC on Soft Robotics. She founded and served as General Chair for the IEEE-RAS First International Conference on Soft Robotics. She was among the founders of RoboTech srl, spin-off company of the Scuola Superiore Sant’Anna, in the sector of edutainment robotics.
Plenary Talk III

Challenges and Opportunities for Robotics

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Abstract

We are facing global issues, such as population aging, global warming, urbanization, pandemic, etc. Many of the issues are very difficult to solve by today’s technology. We need to overcome the issues to survive through advancement of science and technology. Robotics is one of key technologies for solving the issues. In this presentation, we first consider challenges and opportunities of robotics. A robot is a system, which consists of many devices and technologies. A new robot for a new field could not be created by combining existing devices and technologies. We need to create/enrich devices/technologies to meet requirements of each field. We then discuss how the robotic foundations will be enhanced through the development of new robots in new fields. Several robot systems developed in our laboratory are introduced, which include multiple mobile-robots coordination, physical human-robot interaction, co-worker robots, universal manipulation, etc. Some of these research results have been successfully used in real applications and some of them have not been used yet. The research examples from our laboratory illustrate the issues for development of robots in new fields and importance of mechanism design for realistic robot systems.

Biography

Professor Kazuhiro Kosuge is Distinguished Professor of Tohoku University, in the Department of Robotics, Tohoku University, Sendai, Japan. He received the B.S., M.S., and Ph.D. degrees in control engineering from Tokyo Institute of Technology in 1978, 1980, and 1988 respectively. From 1980 through 1982, he was with DENSO Co., Ltd. After having served as a Research Associate at Tokyo Institute of Technology and an Associate Professor at Nagoya University, he has been serving as a Professor at Tohoku University since 1995. For more than 35 years, he has been conducting research on robotics. He served as Science Advisor, Research Promotion Bureau, Ministry of Education, Culture, Sports, Science and Technology, Japan (2010-2014), Senior Program Officer, Japan Society of Promotion of Science (2007-2010), and Selected Fellow, Center for Research and Development Strategy, Japan Science and Technology Agency (2005-2012). He also served as IEEE Division X Director for 2015-2016, and IEEE Robotics and Automation Society President for 2010-2011. He is IEEE Fellow, JSME Fellow, SICE Fellow, RSJ Fellow, JSAE Fellow, and a member of Engineering of Academy, Japan. He is a 2018 recipient of Medal of Honor, Medal with Purple Ribbon, awarded with the name of Emperor, from the Government of Japan. He is 2020 Vice President for Technical Activities, IEEE.
Keynote Talk I

Nonlinear Observer Design and Some Interesting Applications in Autonomous Systems

Speaker | Rajesh Rajamani
---|---
Time | 11:40 AM – 12:20 PM, July 7, 2020 (US EDT)
Location | Room T13

Abstract

This talk centers on the theme that simple inexpensive sensors can be combined with well-designed model-based estimation algorithms to create sophisticated monitoring devices for smart mechanical systems. First, the design of stable observers for nonlinear systems is discussed and an overview of some popular design techniques is presented. Two recent nonlinear observer results are then discussed – one on a new observer design method that combines the advantages of the high-gain and LMI/LPV design algorithms and the other on the use of switched gains to provide globally stable observers for non-monotonic nonlinear systems. This is followed by presentation of practical applications involving interesting estimation problems, including a smart bicycle that automatically tracks the trajectories of nearby vehicles on the road to protect itself and smart agricultural/construction vehicles that utilize inexpensive sensors for end-effector position estimation. Videos of experimental demonstrations in these applications are presented and commercialization aspects of product prototypes are discussed.

Biography

Professor Rajesh Rajamani obtained his M.S. and Ph.D. degrees from the University of California at Berkeley and his B.Tech. degree from the Indian Institute of Technology at Madras. He joined the faculty in Mechanical Engineering at the University of Minnesota in 1998 where he is currently the Benjamin Y.H. Liu -TSI Endowed Chair Professor and Associate Director (Research) of the Minnesota Robotics Institute. His active research interests include estimation, sensing and control for smart mechanical systems. Dr. Rajamani has co-authored over 150 journal papers and is a co-inventor on 16 patents/ patent applications. He is a Fellow of ASME and has been a recipient of the CAREER award from the National Science Foundation, the Ralph Teetor Award from SAE, the O. Hugo Schuck Award from the American Automatic Control Council, and a number of best paper awards from journals and conferences. Several inventions from his laboratory have been commercialized through start-up ventures co-founded by industry executives. One of these companies, Innotronics, was recently recognized among the 35 Best University Start-Ups of 2016 in a competition conducted by the US National Council of Entrepreneurial Tech Transfer.
Keynote Talk II

Adaptive Structure and Facades in Civil Engineering – a New Field for Intelligent Mechatronics

Abstract

The building sector consumes currently more than 40% of global resources and energy. Projecting the demand of buildings according to the increasing world population lead to significant resource problems in the near future. Therefore, increasing efficiency and reducing resources in the building sector is a crucial task. Adaptivity of the load bearing structures as well as the façade elements offers a high potential to reduce grey energy due to ultra light-weight load bearing structures respectively new ideas concerning energy reduced building elements and comfort oriented climate control. In the talk a systems engineering view on the specific problems in adaptive buildings is given. After introducing different principles to manipulate the structure of a building with actuators, the control system in the background for the active adaptation of the load bearing structure is discussed. This includes the question of sensor and actuator placement, state estimation concept, fault diagnosis and control concept for actuated buildings. In case of building elements the general problem of dramatically reduced thermal mass due to the use of light weight sandwich façade elements has to be considered for the complete climate control approach. The results will be demonstrated in a 36 m high rise multi-storey building.

Biography

Professor Oliver Sawodny received his Dipl.-Ing. degree in electrical engineering from the University of Karlsruhe, Karlsruhe, Germany, in 1991 and his Ph.D. degree from the University of Ulm, Ulm, Germany, in 1996. In 2002, he became a Full Professor at the Technical University of Ilmenau, Ilmenau, Germany. Since 2005, he has been the Director of the Institute for System Dynamics, University of Stuttgart, Stuttgart, Germany. His current research interests include methods of differential geometry, trajectory generation, and applications to mechatronic systems. He received important paper awards in major control application journals such as Control Engineering Practice Paper Prize (IFAC, 2005) and IEEE Transaction on Control System Technology Outstanding Paper Award (2013). He is a senior member of IEEE and Senior Editor of Mechatronics.
Keynote Talk III

Research on Human Kinesiology and Wearable Robot

Speaker  Caihua Xiong

Time    11:40 AM – 12:20 PM, July 8, 2020 (US EDT)

Location Room T13

Abstract

How to design an artificial equipment so that its motion functions match the ones of the natural system, and forming a human-mechatronic system, is still a challenging. This presentation introduces a methodology of designing human-mechatronic integrated equipment according to the mechanisms of human limb movement. The mechanically replicating method of the human movement is explored with an example of designing a robot hand. The movement mechanisms, including the movement synergic characteristics and the kinesiology of the musculoskeletal system of the human upper extremity, are studied. A design method of an anthropomorphic hand, which endows the designed hand with natural grasping functions, is developed. The experimental results show that the designed hand can replicate not only human grasping activities of daily living but also the natural grasping behaviors of the human hand. The design principle of the rehabilitation robot is formed from the exploration of replicating mechanically the natural grasping functions of the human hand. An exoskeleton rehabilitation robot for upper extremity is developed with the similar design idea of the anthropomorphic hand. Finally, a general framework of reproducing the configuration trajectory of arm-hand in the spatiotemporal profile is proposed.

Biography

Professor Caihua Xiong received the Ph.D. degree in mechanical engineering from Huazhong University of Science and Technology (HUST), Wuhan, China, in 1998. From 1999 to 2003, he was with the City University of Hong Kong, Chinese University of Hong Kong, as a postdoctoral fellow, and Worcester Polytechnic Institute, Worcester, MA, USA, as a Research Scientist. He is the Chang Jiang Professor appointed by the Ministry of Education of China, the owner of National Science Fund for Distinguished Young Scholars of China, and the director of the Institute of Robotics Research (IR2) in HUST. He has published more than 100 papers in some international journals such as International Journal of Robotics Research, IEEE Transactions on Robotics, Proceedings of the Royal Society B, Journal of Theoretical Biology, IEEE/ASME Transactions on Mechatronics, IEEE Transactions on Cybernetics, IEEE Transactions on Automation Science and Engineering and etc. He was authorized more than 30 invention patents related to rehabilitation robots and robotic prosthetic hands. His current research interests include the natural movement in creatures and its mechanical replication principle, wearable robotics, and rehabilitation robotics.
Keynote Talk IV

Making Better Sense Out of Mechanical Contacts

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<th>Soo Jeon</th>
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<td>Location</td>
<td>Room T14</td>
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Abstract

Estimation of mechanical properties such as weight, 3D shape or stiffness distribution requires gathering data through mechanical contacts, often in a sequential way. Applications abound in industry, and each application poses unique technical challenges in terms of how to collect and process the data for desired objectives. This talk will overview some of recent projects that fall within this category and illustrate how we drew on signal processing and statistical inference to address practical issues associated with them. Applications to be covered include distributed weight estimation for logistics, elastography for portable ultrasound, precision airdrop for UAVs (Unmanned Aerial Vehicles) and tactile exploration with robotic hand for shape and stiffness estimation of 3D object. While linear methods (e.g. recursive least square (RLS) or sparse reconstruction) can still be effective for many applications, estimation of more complex entities (e.g. velocity field, 3D shape or stiffness distribution) suggests nonlinear data-driven approaches such as Gaussian process regression (GPR) combined with active sampling strategies for sample efficiency. For each case, key issues and attempted solutions will be presented followed by performance evaluation.

Biography

Professor Soo Jeon received his B.S. and M.S. degrees from Mechanical & Aerospace Engineering at Seoul National University, Korea in 1998 and 2001 respectively, and his Ph.D. degree from Mechanical Engineering at University of California, Berkeley in 2007. After graduation, he worked as a mechanical engineer in Applied Materials Inc. until he moved to Department of Mechanical & Mechatronics Engineering at University of Waterloo in 2009 where he is currently an associate professor. His research interests include dynamic systems and control, mechatronic system design, friction-induced stability and machine learning for physical systems. Applications of his research cover robotics, industry automation, medical ultrasound, and transportation systems. He received Rudolf Kalman Best Paper Award from ASME Dynamic Systems and Control Division in 2010, and Discovery Accelerator Supplement Award from NSERC (Natural Sciences and Engineering Research Council) of Canada in 2015. He is a member of ASME, IEEE, CSME (Canadian Society for Mechanical Engineering) and PEO (Professional Engineers Ontario). He has been an associate editor for ASME Journal of Dynamic Systems, Measurement and Control, IEEE Transactions on Automation Science and Engineering, and IEEE/ASME Transactions on Mechatronics (Guest Associate Editor).
## Best Conference Paper Award Finalists

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<td>TuAT11.2</td>
<td>A Closed-Loop Controller for a Continuum Surgical Manipulator Based on a Specially Designed Wrist Marker and Stereo Tracking</td>
<td>Haozhe Yang, Baibo Wu, Xu Liu, Kai Xu, Shanghai Jiaotong Univ., China</td>
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<td>TuAT11.4</td>
<td>Active Handheld Flexible Fetoscope – Design and Control Based on a Modified Generalized Prandtl-Ishlinski Model</td>
<td>Julie Legrand, Dries Dirckx, Maarten Durt, Mouloud OURAK, Jan Deprest, Sebastien Ourselin, Qian Jun, Tom Vercauteren, Emmanuel B Vander Poorten, KU Leuven, Belgium</td>
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<td>TuAT9.5</td>
<td>Redundant Haptic Interfaces for Enhanced Force Feedback Capability Despite Joint Torque Limits</td>
<td>Ali Torabi, Kourosh Zareinia, Garnette Sutherland, Mahdi Tavakoli, Univ. of Alberta, Canada</td>
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<td>WeAT11.3</td>
<td>Reconfigurable Impedance Sensing System for Early Rehabilitation Following Stroke Recovery</td>
<td>Jingjing Ji, Yiyuan Qi, Jiahao Liu, Kok-Meng Lee, Huazhong Univ. of Sci. &amp; Tech., China and Georgia Tech, USA</td>
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<tr>
<td>WeAT11.5</td>
<td>Lower-Body Walking Motion Estimation Using Only Two Shank-Mounted Inertial Measurement Units (IMUs)</td>
<td>Tong Li, Lei Wang, Qingguo Li, Tao Liu, Zhejiang Univ., China</td>
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<td>TuAT11.1</td>
<td><em>Quasi Direct Drive Actuation for a Lightweight Hip Exoskeleton with High Backdrivability and High Bandwidth</em></td>
<td>Shuangyue Yu*, Tzu-Hao Huang, Xiaolong Yang, Chunhai Jiao, Jianfu Yang, Hang Hu, Sainan Zhang, Yue Chen, Jingang Yi, Hao Su</td>
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<td>TuAT2.3</td>
<td><em>Underwater Buoyancy and Depth Control Using Reversible PEM Fuel Cells</em></td>
<td>Alicia Keow*, Wenyu Zuo, Fathi Ghorbel, Zheng Chen</td>
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<td>WeAT11.1</td>
<td><em>A Novel Pantographic Exoskeleton based Collocated Joint Design with Application for Early Stroke Rehabilitation</em></td>
<td>Jiaoying Jiang*, Wenjing Li, Kok-Meng Lee</td>
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<td>WeAT4.2</td>
<td><em>Provably Stabilizing Controllers for Quadrupedal Robot Locomotion on Dynamic Rigid Platforms</em></td>
<td>Amir Iqbal*, Yuan Gao, Yan Gu</td>
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<td>WeAT7.4</td>
<td><em>Fingertip Position and Force Control for Dexterous Manipulation through Model-Based Control of Hand-Exoskeleton-Environment</em></td>
<td>Paria Esmatloo*, Ashish Deshpande</td>
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Description

In this competition, undergraduate student teams from different scientific disciplines and of various backgrounds were invited to propose and demonstrate creative solutions to a specified real-life problem related to mechatronic systems and engineering. The purpose of the competition is to foster educational and research interest in mechatronics, create a forum for students to share their innovative ideas, and provide the mechatronics community with new perspectives on design and fabrication. Projects could be proposed in the following categories:

General Submission: In this track, novel solutions that incorporate cutting edge technologies and take advantage of the considerable advances in mechatronics research were proposed. Topics of interest included: intelligent systems, control systems, cyber-physical systems, micro-electro-mechanical systems, human-machine interfaces, robotics, smart materials and structures, etc.

Special Track on Networked Computing Infrastructure: In this track, innovative projects in the areas of computing, control, and communications for ground or air mobile platforms or edge applications were proposed. Teams must use Jetson TX2 embedded systems platform to develop solutions. Hardware and software technical support was provided by the organizers supported of the Networked Airborne Computing team funded by US National Science Foundation through awards 1730675, 1730589, 1730570 and 1730325. Please see the link for more information: http://www.uta.edu/utari/research/robotics/airborne/index.php.
### Student Teams

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<td>Liu, Xiangzhi; Li, Yisong</td>
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<th>WeSD.2</th>
<th>Turbo Micromouse – the Smart Maze Navigating Robot with a Suction Fan</th>
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<td>Liu, Yingshu; Liu, He; Wang, Lei; Cheng, Guo</td>
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<th>Autonomous Scaled Race-Car Platform for Safe Aggressive Vehicle Maneuvers (RU-Racer)</th>
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<td>Jelvani, Alborz; Duma, Dimitri; Arab, Aliasghar; Chen, Kuo; YU, JIAXING; Yi, Jingang</td>
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<th>WeSD.5</th>
<th>Development of a Bikebot with Mobile Manipulator for Evaluation and Intervention Systems for Densely-Grown Horticultural Crops</th>
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<td>Jelvani, Alborz; Edmonds, Merrill; Gong, Yongbin; Chen, Kuo; Yi, Jingang</td>
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<td>Syrymova, Togzhan; Burunchina, Karina; Novossyolov, Valeriy; Seitzhan, Saltanat; Kappassov, Zhanat</td>
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<th>WeSD.7</th>
<th>Pulley-Assisted Actuation for Cable-Driven Soft Robots</th>
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<td>Wechter, Benjamin; Meglathery, Kevin Thomas; Cesarano, Matthew Owen; Kallok, Robert Andrew; Trkov, Mitja</td>
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<th>WeSD.8</th>
<th>Piezoelectric Device for Inducing Strain on Cell Samples</th>
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<td>Carlisle, Nicholas; Venkatesh, Siddharth; yeo, Andrew; Avci, Ebubekir; Rosset, Samuel</td>
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<td>WeSD.10</td>
<td><em>Exploiting Quasi-Direct Drive Actuation in a Knee Exoskeleton for Effective Human-Robot Interaction</em></td>
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<td>Phung, Peter; Di Lallo, Antonio; Su, Hao</td>
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1 Reviewers of TMech/AIM Emerging Topics are not included in this list.
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Call for papers for the 2021 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM 2021)

The 2021 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM 2021) will be held on July 12-16, 2021 in Delft, with an additional virtual option. The motto will be “sustainable mechatronics.”

As a flagship conference focusing on mechatronics and intelligent systems, the AIM 2021 will bring together an international community of experts to discuss the state of the art, new research results, perspectives of future developments, and innovative applications relevant to mechatronics, robotics, automation, industrial electronics, and related areas, not limited to the conference motto. The sponsors and organizers of AIM 2021 invite submissions of high-quality mechatronics research papers describing original work, including but not limited to the following topics: Actuators, Automotive Systems, Bioengineering, Control, Data Storage Systems, Energy Harvesting, Energy-Saving Technology, Electronic Packaging, Failure Diagnosis, Human-Machine Interfaces, Industry Applications, Information Technology, Intelligent Systems, Machine Vision, Manufacturing, Micro-Electro-Mechanical Systems, Micro/Nano Technology, Modeling and Design, System Identification and Adaptive Control, Motion Control, Vibration and Noise Control, Opto-Electronic Systems, Optomechatronics, Prototyping, Real-Time and Hardware-in-the-Loop Simulation, Robotics, Sensors, Smart Materials and Structures, Sustainability in Mechatronics, System Integration, Transportation Systems, and frontier fields.

Detailed information about paper submission will be published on http://aim2021.org. All topics are welcome within the scopes of TMech: www.ieee-asme-mechatronics.org and AIM 2021. Authors are invited to submit one of the following:

**TMECH/AIM Focused Section Papers:** Submissions to the Second Edition of the Focused Section on TMECH/AIM Emerging Topics (renamed from previously TMECH/AIM Concurrent Submission) are done through the TMECH site https://mc.manuscriptcentral.com/tmech-ieee. Accepted TMECH/AIM Focused Section papers will be presented at AIM 2021 and published in the Second Edition of TMECH/AIM Focused Section in the August Issue of TMECH in 2021. The publication in the dedicated Issue of TMECH, however, will be subject to the presentation of the paper at AIM 2021 with paid registration fee. Papers rejected for publication in TMECH will still be considered by the Program Committee of AIM 2021, which makes a final acceptance/rejection decision for AIM 2021. For more details about submission/review procedures and timelines, please refer to the Call for Papers for TMECH/AIM Focused Section: http://www.ieee-asme-mechatronics.info/section-sections/

**AIM Contributed and Invited Papers:** All papers go through a rigorous review process. Accepted papers will be presented by their authors at the conference. All accepted peer-reviewed manuscripts will be published in the conference proceedings, and will be submitted for inclusion in IEEEExplore, subject to formatting and copyright requirements.

**Tutorials & Workshops:** Proposals are invited for half-day or full-day tutorials and workshops. Workshops explore the frontiers of recent or emerging topics in mechatronics, while tutorials provide a foundation for future self-study in important areas of mechatronics. Tutorial and workshop proposals must include: (1) a statement of objectives, (2) a description of the intended audience, (3) a list of speakers with an outline of their planned presentations. Unless specifically requested, individual tutorial and workshop presentations are not peer-reviewed and do not appear in the proceedings. Proposals are invited for invited and special sessions. Invited sessions consist of 4 to 6 thematically related invited papers. Invited session proposals consist of a brief statement of purpose and extended abstracts of the included invited papers. Invited papers are submitted and reviewed following the same process as contributed papers, and are included in the proceedings.

**Invited & Special Sessions:** Proposals are invited for invited and special sessions. Invited sessions consist of 4 to 6 thematically related invited papers. Invited session proposals consist of a brief statement of purpose and extended abstracts of the included invited papers. Invited papers are submitted and reviewed following the same process as contributed papers, and are included in the proceedings. All contributed and invited papers, tutorial and workshop proposals, and invited and special session proposals for AIM2021 must be uploaded through http://ras.papercept.net according to the deadlines below.

**Submission of AIM Contributed & Invited Papers:**
- **Close:** 5 Dec 2021
- **Open:** 1 Nov 2021

**Submission of Special & Invited Session Proposals:**
- **15 Jan 21**

**Submission of Tutorial & Workshop Proposals:**
- **15 Jan 21**

**Notification of AIM Contributed & Invited Papers:**
- **1 Feb 21**

**Final Paper Submission AIM 2021:**
- **15 May 21**

Contact: aim2021@aim2021.org | Conference Website: http://aim2021.org
First Announcement:

Call for Papers

The Second Edition of Focused Section on TMECH/AIM Emerging Topics

Submissions are called for the Second Edition of Focused Section (FS) on TMECH/AIM Emerging Topics (renamed from previous TMECH/AIM Concurrent Submission). This Focused Section is intended to expedite publication of novel and significant research results or technology breakthrough of emerging topics within the scopes of TMECH (www.ieee-asme-mechatronics.org). It also provides the rapid access to the state-of-the-art of TMECH publications within the mechatronics community.

The submitted paper must not exceed 8 TMECH published manuscript pages, excluding photos and bios of authors, and will be subject to a normal peer review process in the standard of TMECH. All accepted papers from submissions to the Focused Section will be published in August Issue of TMECH in 2021 and will be presented in the 2021 IEEE/ASME International Conference on AIM. The rejected papers from submissions will be transferred to the Program Committee of AIM 2021 to be further reviewed and considered as contributed conference papers.

The review process for submissions to the Focused Section will be conducted with one round of Major/Minor Revision allowed, and the final decision falls into one of the following two categories:

1. Accept for publication in Focused Section. In this case, the paper will be accepted by AIM 2021 concurrently for presentation only with full information of the paper to be included in the preprinted proceeding of AIM 2021. The final publication in TMECH, however, will be subject to the completion of presentation in AIM 2021 with paid full registration fee.

2. Reject for publication in Focused Section (in the first and second round). In this case, the paper, as well as all review comments, will be forwarded to the Program Committee of AIM 2021 for further consideration. A final Accept/Reject decision will then be made by the Committee as a contributed conference paper for AIM 2021.

Manuscript preparation

Papers must contain original contributions and be prepared in accordance with the journal standards. Instructions for authors are available online on the TMECH website.

Manuscript submission

Manuscripts should be submitted to TMECH online at: mc.manuscriptcentral.com/tmech-ieee, selecting the track ‘TMECH/AIM Emerging Topics’. The cover letter should include the following statement: This paper is submitted to the Second Edition of Focused Section on TMECH/AIM Emerging Topics. The full information of the paper should be submitted concurrently to AIM 2021 online at: ras.papercept.net/conferences/scripts/start.pl, noted with the given TMECH manuscript number.

Submission/Review/Decision Timeline (tentative):

- Opening Date of TMECH/AIM FS Submission Site (first submission): November 1, 2020
- Closing Date of TMECH/AIM FS Submission Site (first submission): December 5, 2020
- Full Information of TMECH/AIM FS Paper Submitted to AIM Site: December 5, 2020
- First Decision for TMECH/AIM FS Submission: March 1, 2021
- Revised TMECH/AIM FS Submission Due by: March 26, 2021
- Final Decision for TMECH/AIM FS Submission: May 1, 2021
- Final Version of TMECH/AIM FS Submission Due by: May 15, 2021
- Publication of Focused Section in TMECH: August 2021

Contacts: Send enquiries about this Announcement to Xiang Chen, xchen@uwindsor.ca, Senior Editor of TMECH.
# Program at a Glance

## AIM 2020 Technical Program Monday July 6, 2020

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<thead>
<tr>
<th>Lunch</th>
<th>WP1</th>
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<th>WP3</th>
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<td>Workshop III</td>
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12:20-13:30 MoLB  
Room T24, T25, T26  
**Lunch Break - Day 1**

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<td>08:45-09:00</td>
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<td>09:00-10:00</td>
<td>TuPL Plenary Session 1</td>
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<td>10:00-10:15</td>
<td>TuTCB Virtual Coffee Break 1</td>
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<td>10:15-11:30</td>
<td>TuAT1 Magnetic Sensors and Actuators</td>
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<td>10:15-11:30</td>
<td>TuAT2 Modeling and Control of Actuators</td>
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<td>10:15-11:30</td>
<td>TuAT3 Room T3 Legged Robots I</td>
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<td>10:15-11:30</td>
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<td>10:15-11:30</td>
<td>TuAT6 Room T6 Tactile and Force Sensing</td>
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## AIM 2020 Technical Program Wednesday July 8, 2020

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### Track Breakdown

- **Track T1**: 10:15-11:30 WeAT1 Novel Smart Material Actuators
- **Track T2**: 10:15-11:30 WeAT2 Modeling and Design of Mechatronic Systems I
- **Track T3**: 10:15-11:30 WeAT3 Aerial Robots I
- **Track T4**: 10:15-11:30 WeAT4 Mobile Robots II
- **Track T5**: 10:15-11:30 WeAT5 Soft Mechatronic Systems II
- **Track T6**: 10:15-11:30 WeAT6 Series and Parallel Elastic Actuators
- **Track T7**: 10:15-11:30 WeAT7 Robotic Manipulators I
- **Track T8**: 10:15-11:30 WeAT8 Vehicle Control
- **Track T9**: 10:15-11:30 WeAT9 Bio-Inspired Actuators and Robots
- **Track T10**: 10:15-11:30 WeAT10 Planning and Navigation I
- **Track T11**: 10:15-11:30 WeAT11 Rehabilitation Robots I
- **Track T12**: 10:15-11:30 WeAT12 Fault and Anomaly Detection

### Additional Sessions

- **Virtual Coffee Break**
- **Lunch Break - Day 3**

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**Note:** The table represents the schedule for the technical sessions and keynotes. Each track number corresponds to a specific session, and the locations are specified in the corresponding sections of the schedule. The times are indicated in the format of hours and minutes.
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AIM 2020 Content List

Technical Program for Monday July 6, 2020

MoWPAT1 (Workshop/Tutorial Session) Room W1

Chair: BAI, Kun Huazhong University of Science and Technology
Co-Chair: Foong, Shaohui Singapore University of Technology and Design

09:00-12:20 MoWPAT1.1

Advanced Magneto-Mechatronics Systems: Modeling, Sensing and Control*.

BAI, Kun Huazhong University of Science and Technology
Foong, Shaohui Singapore University of Technology and Design
Lin, Chun-Yeon National Taiwan University
Chen, Si-Lu Professor, Institute of Advanced Manufacturing Technology, Ningbo Institute of Industrial Technology, CAS
Li, Min Minnesota State University

MoWPAT2 (Workshop/Tutorial Session) Room W2

Chair: Downs, Anthony NIST
Co-Chair: Harrison, William University of Michigan

09:00-12:20 MoWPAT2.1

Agile Robotics for Industrial Automation Competition*.

Downs, Anthony NIST
Harrison, William University of Michigan
Schlenoff, Craig NIST

MoWPAT3 (Workshop/Tutorial Session) Room W3

Chair: Su, Hao City University of New York, City College
Co-Chair: Chen, YuFeng Massachusetts Institute of Technology

09:00-12:20 MoWPAT3.1

Challenges and Opportunities of Soft Robotics: Research, Applications, and Education*.

Su, Hao City University of New York, City College
Chen, YuFeng Massachusetts Institute of Technology
Di Lallo, Antonio Università di Pisa

MoWPAT4 (Workshop/Tutorial Session) Room W4

Chair: Guo, Jiajie Huazhong University of Science and Technology
Co-Chair: Lan, Chao-Chieh National Cheng Kung University

09:00-12:20 MoWPAT4.1

Flexible Mechatronics for Robotics*.

Guo, Jiajie Huazhong University of Science and Technology
Lan, Chao-Chieh National Cheng Kung University
Wang, Qining Peking University
Chen, Gumin Xidian University

MoWPAT5 - Part 1 (Workshop/Tutorial Session) Room W5

Chair: Vatsal, Vighnesh Cornell University
Co-Chair: Hoffman, Guy Cornell University

09:00-12:20 MoWPAT5.1

Supernumerary Robotic Devices*.

Vatsal, Vighnesh Cornell University
Hoffman, Guy Cornell University
## Technical Program for Tuesday July 7, 2020

### TuPL

#### Plenary Session 1 (Plenary Session)

Chair: Chen, Xiang  
University of Windsor  

09:00-10:00  
TuPL.1  


Lee, Kok-Meng  
Georgia Institute of Technology

### TuAT1

#### TuAT1.1  

- Sado, Keita  
Chuo University  
- Deguchi, Yusuke  
Chuo University  
- Nagatsu, Yuki  
Chuo University  
- Hashimoto, Hideki  
Chuo University

10:15-10:30  
TuAT1.2  

Data-Driven Multi-Objective Controller Optimization for Magnetically-Levitated Positioning Stage, pp. 7-17.

- Li, Xiaocong  
A*STAR  
- Zhu, Haiyue  
Singapore Institute of Manufacturing Technology  
- Ma, Jun  
National University of Singapore  
- Teo, Tat Joo  
Singapore Institute of Manufacturing Technology  
- Teo, Chek Sing  
SIMTech  
- Tomizuka, Masayoshi  
University of California  
- Lee, Tong Heng  
National University of Singapore

10:30-10:45  
TuAT1.3  


- Lin, Chun-Yeon  
National Taiwan University  
- Wu, Yi-Chin  
National Taiwan University  
- Chen, Yuan-Liang  
National Taiwan University  
- Huang, shih cheng  
National Taiwan University

10:45-11:00  
TuAT1.4  


- Arthur, Khalid  
University of New Hampshire  
- Yoon, Se Young (Pablo)  
University of New Hampshire

11:00-11:15  
TuAT1.5  

Noncontact Steering of Magnetic Objects by Optimal Linear Feedback Control of Permanent Magnet Manipulators, pp. 30-35.

- Riahi, Nayereh  
Southern Illinois University  
- Komaee, Arash  
Southern Illinois University, Carbondale

### TuAT2

#### TuAT2.1

Hybrid Model Based on the Maxwell-Slip Model and a Support Vector Machine for Hysteresis in Piezoelectric Actuators, pp. 36-41.

- Xie, Shaobiao  
Shanghai Academy of Spaceflight Technology  
- Ni, Chenrui  
Harbin Institute of Technology  
- Duan, Haiyan  
Beijing Institute of Space Mechanics & Electricity  
- Liu, Yanfang  
Harbin Institute of Technology  
- Qi, Naiming  
Harbin Institute of Technology

10:15-10:30  
TuAT2.2  


- Lyu, Litong  
Zhejiang University  
- Chen, Zheng  
Zhejiang University  
- Yao, Bin  
Zhejiang University

10:30-10:45  
TuAT2.3  

Underwater Buoyancy and Depth Control Using Reversible PEM Fuel Cells, pp. 54-59.

- Keow, Alicia Li Jen  
University of Houston  
- Zuo, Wenyu  
University of Houston  
- Ghorbel, Fathi  
Rice University  
- Chen, Zheng  
University of Houston

10:45-11:00  
TuAT2.4  


- Lin, Ming-Tsung  
National Formosa University  
- Lai, Han-Yu  
National Formosa University  
- Liu, Kuang-Chih  
National Formosa University  
- Lee, Jih-Chieh  
National Formosa University  
- Lee, Chien-Yi  
Industrial Technology Research Institute

11:00-11:15  
TuAT2.5  

Distributed Control Strategies for Modular Permanent Magnet Synchronous Machines Taking into Account Mutual Inductances, pp. 66-71.

- Verkroost, Lynn  
Ghent University  
- Vansompel, Hendrik  
Ghent University  
- De Belie, Frederik  
Ghent University  
- Sergeant, Peter  
Ghent University

### TuAT3

#### TuAT3.1

Modeling and Control of Actuators (Regular Session)

Chair: Chen, Zheng  
Zhejiang University  
Co-Chair: Liu, Yanfang  
Harbin Institute of Technology

10:15-10:30  
TuAT3.1  


Lee, Kok-Meng  
Georgia Institute of Technology

10:30-10:45  
TuAT3.2  

Hybrid Model Based on the Maxwell-Slip Model and a Support Vector Machine for Hysteresis in Piezoelectric Actuators, pp. 36-41.

- Xie, Shaobiao  
Shanghai Academy of Spaceflight Technology  
- Ni, Chenrui  
Harbin Institute of Technology  
- Duan, Haiyan  
Beijing Institute of Space Mechanics & Electricity  
- Liu, Yanfang  
Harbin Institute of Technology  
- Qi, Naiming  
Harbin Institute of Technology

10:45-11:00  
TuAT3.3  


- Lyu, Litong  
Zhejiang University  
- Chen, Zheng  
Zhejiang University  
- Yao, Bin  
Zhejiang University

11:00-11:15  
TuAT3.4  

Underwater Buoyancy and Depth Control Using Reversible PEM Fuel Cells, pp. 54-59.

- Keow, Alicia Li Jen  
University of Houston  
- Zuo, Wenyu  
University of Houston  
- Ghorbel, Fathi  
Rice University  
- Chen, Zheng  
University of Houston

11:15-11:30  
TuAT3.5  

Distributed Control Strategies for Modular Permanent Magnet Synchronous Machines Taking into Account Mutual Inductances, pp. 66-71.

- Verkroost, Lynn  
Ghent University  
- Vansompel, Hendrik  
Ghent University  
- De Belie, Frederik  
Ghent University  
- Sergeant, Peter  
Ghent University
**Legged Robots I (Regular Session)**

Chair: Yamakita, Masaki  
Co-Chair: Fujimoto, Yasutaka

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<tr>
<td>10:15-10:30</td>
<td>TuAT3.1</td>
<td>Bipedal Walking Based on Improved Spring Loaded Inverted Pendulum Model with Swing Leg (SLIP-BL), pp. 72-77.</td>
<td>PELIT, Mustafa Melih, Chang, Junho, Takano, Rin, Yamakita, Masaki</td>
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<td>TuAT3.2</td>
<td>Strict Stealth Walking of Planar Point-Footed Biped with Extra Control Torques, pp. 78-84.</td>
<td>Asano, Fumihiro, Kondo, Ryosuke, Shibata, Hiroki</td>
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<td>Optimization and Comparison of Human and Avian Robotic Walking, pp. 85-90.</td>
<td>Carnier, Rodrigo M., Fujimoto, Yasutaka</td>
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<td>Niu, Zhenyu, LIU, HAO, Haoshu, Cheng, Pingang, Han</td>
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**Mobile Robots I (Regular Session)**

Chair: Zhang, Feitian  
Co-Chair: Wada, Masayoshi

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**TuAT5**

Room T5  

Chair: Liu, Chih-Hsing  
Co-Chair: Qi, Peng

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<td>10:30-10:45</td>
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<td>10:45-11:00</td>
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**Soft Mechatronics I (Regular Session)**

Chair: Liu, Chih-Hsing  
Co-Chair: Qi, Peng

**STEP: A New Mobile Platform with 2-DOF Transformable Wheels for Service Robots**, pp. 111-118.

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Lee, Yunhyuk  
Lee, Seungmin  
Kim, Jongwon  
Kim, Hwa Soo  
Seo, TaeWon

Kim, Youngsoo  
Lee, Yunhyuk  
Lee, Seungmin  
Kim, Jongwon  
Kim, Hwa Soo  
Seo, TaeWon

11:00-11:15 TuAT4.4  

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Wang, Yanhui  
Zhang, Bolun  
Wang, Guangli  
Liu, Tao  
Yi, Jingang  
Han, Meimei

Wang, Zenghao  
Wang, Yanhui  
Zhang, Bolun  
Wang, Guangli  
Liu, Tao  
Yi, Jingang  
Han, Meimei

11:15-11:30 TuAT4.5  


Dang, Fengying  
Nasreen, Sanjida  
Zhang, Feitian

Dang, Fengying  
Nasreen, Sanjida  
Zhang, Feitian

11:15-11:30 TuAT4.5  

Model-Based Control of a Novel Planar Tendon-Driven Joint Having a Soft Rolling Constraint on a Plane, pp. 132-137.

Masuya, Ken  
Tahara, Kenji

Masuya, Ken  
Tahara, Kenji

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A Soft Pneumatic Crawling Robot with Unbalanced Inflation, pp. 138-143.

Wang, Naijia  
He, Mengqi  
Cui, Yushi  
Sun, Yi  
Qi, Peng

Wang, Naijia  
He, Mengqi  
Cui, Yushi  
Sun, Yi  
Qi, Peng

10:45-11:00 TuAT5.3  


Liu, Chih-Hsing  
Chung, Fu-Ming  
Chen, Yang  
Chiu, Chen-Hua  
Chen, Ta-Lun

Liu, Chih-Hsing  
Chung, Fu-Ming  
Chen, Yang  
Chiu, Chen-Hua  
Chen, Ta-Lun

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Liu, Yonggan
School of Mechatronic Engineering and Automation, Shanghai Unive
Yang, Yang
Shanghai University
Peng, Yan
Shanghai University
zhong, songyi
Shanghai University, Shanghai, China
Pu, Huayan
Shanghai University

11:15-11:30 TuAT5.5

Shoani, Mohamed
Universiti Tun Hussein Onn Malaysia
Ribuan, Mohamed Najib
Universiti Tun Hussein Onn Malaysia
Mohd Faudzi, Ahmad ‘Athif
Universiti Teknologi Malaysia

11:30-11:45 TuAT6.2

Tran Phuong, Thao
Nagaoka University of Technology
Ohishi, Kiyoshi
Nagaoka University of Technology
Yokokura, Yuki
Nagaoka University of Technology

10:15-10:30 TuAT6.1

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Syrymova, Togzhan
Nazarbayev University
Massalim, Yerkebulan
Nazarbayev University
Khasisanov, Yerbolat
ISSAI
Kappassov, Zhanat
Pierre and Marie Curie University

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Shanghai Jiao Tong University
Han, Yong
Shanghai Jiao Tong University
Wu, Jianhua
Shanghai Jiao Tong University
Xiong, Zhenhua
Shanghai Jiao Tong University

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Li, Xinran
Tongji University
Li, Wanlin
Queen Mary University of London
Zheng, Yu
Tencent
Althoefer, Kaspar
Queen Mary University of London
Qi, Peng
Tongji University

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Kappassov, Zhanat
Pierre and Marie Curie University
CORRALES-RAMON, Juan-Antonio
CNRS, SIGMA Clermont, Institut de Mathématiques de Clermont-Ferrand
Perdereau, Véronique
Sorbonne University

10:15-10:30 TuAT7.1

Control of Robotic Manipulators I (Regular Session)
Chair: Mareczek, Joerg University of Applied Sciences of Landshut
Co-Chair: Lee, Min Cheol Pusan National University

10:30-10:45 TuAT7.2

Xi, Ruidong
University of Macau
Yang, Zhi-Xin
University of Macau
Xiao, Xiao
National University of Singapore

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Hu, Jinfeng
Zhejiang University
Li, Chen
Zhejiang University
Chen, Zheng
Zhejiang University
Yao, Bin
Zhejiang University

11:15-11:30 TuAT7.5

Automotive Systems (Regular Session)

TuAT8 Room T8

10:15-10:30 TuAT8.1

Dong, Haoxuan
Zhuang, Weichao
Yin, Guodong
Chen, Hao
Wang, Yan

Southeast University
Southeast University
Southeast University
Southeast University
Southeast University

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Chen, Jian
Lu, Huaxin
Yan, Chizhou
Liu, Zhiyang

Zhejiang University
Zhejiang University
Zhejiang University
Zhejiang University
Zhejiang University

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Zhao, Linhui
Vantsevich, Vladimir

Harbin Institute of Technology
University of Alabama at Birmingham

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Zimmermann, Armin

Robert Bosch GmbH
Robert Bosch GmbH
Ilmenau University of Technology

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Waldner, Mirko
Kraemer, Maximilian
Bertram, Torsten

TU Dortmund University
TU Dortmund University
Technische Universität Dortmund

TuAT9 Room T9

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10:15-10:30 TuAT9.1

Chair: Bi, Luzheng
Co-Chair: ZHANG, Qin

Beijing Institute of Technology
Huazhong University of Science and Technology


10:30-10:45 TuAT9.2

Zhou, Hao
Alici, Gursel

University of Wollongong
University of Wollongong

Wearable Air-Jet Force Feedback Device without Exoskeletal Jet Force Feedback Device without Exoskeletal

10:45-11:00 TuAT9.3

Alici, Gursel
Zhou, Hao

University of Wollongong
University of Wollongong


11:00-11:15 TuAT9.4

ZHANG, Qin
Pi, Te
Liu, Runfeng
Xiong, Caihua

Huazhong University of Science and Technology
Huazhong University of Science and Technology
Huazhong University of Science and Technology
Huazhong Univ. of Science & Tech

TuAT10 Room T10

Machine Vision I (Regular Session)

10:15-10:30 TuAT10.1

Chair: Foong, Shaohui
Co-Chair: Zhang, Xuebo

Singapore University of Technology and Design
Nankai University

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10:30-10:45 TuAT10.2

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Zhang, Xuebo
Chen, Xiang
Fang, Yongchun

Nankai University
Nankai University
University of Windsor
Nankai University


10:45-11:00 TuAT10.3

Okui, Manabu
Masuda, Toshiaki
Tamura, Tomonori
Onozuka, Yuki
Nakamura, Taro

Chuo University
RICOH Company, Ltd
Chuo University
Chuo University
Chuo University
314-321.
Lee, Denzel
Singapore University of Technology and Design

LEE, SHAWNDY MICHAEL
Singapore University of Technology and Design

Liu, Jingmin
Singapore University of Technology & Design

Foong, Shaohui
Singapore University of Technology and Design

10:45-11:00 TuAT10.3
Lei, Zike
Wuhan University of Science and Technology

Chen, Xiang
University of Windsor

Chen, Xi
Wuhan University of Science and Technology

Chai, Li
Wuhan University of Science and Technology

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Ng, Matthew
Singapore University of Technology and Design

Tang, Emmanuel
Singapore University of Technology & Design

Soh, Gim Song
Singapore University of Technology and Design

Foong, Shaohui
Singapore University of Technology and Design

11:15-11:30 TuAT10.5
Benson, Michael
Villanova University

Nikolaidis, Jonathan
Villanova University

Clayton, Garrett
Villanova University

10:45-11:00 TuAT11.3
Jang, Namseon
Korea Institute of Science and Technology

Ihn, Yong Seok
Korea Institute of Science and Technology

Choi, Nara
KIST

Gu, Gangyong
POSTECH

Jeong, Jinwoo
Korea Institute of Science and Technology

Yang, Sungwook
Korea Institute of Science and Technology

Yim, Sehyuk
KIST

Kim, Keehoon
POSTECH, Pohang University of Science and Technology

Oh, Sang-Rok
KIST

Hwang, Donghyun
Korea Institute of Science and Technology

11:00-11:15 TuAT11.4
Legrand, Julie
KULeuven

Dirckx, Dries
KU Leuven

Durt, Maarten
KU Leuven

OURAK, Mouloud
University of Leuven

Deprest, Jan
University Hospital Leuven

Ourselin, Sebastien
University College London

Jun, Qian
KU Leuven

Vercauteren, Tom
King’s College London

Vander Poorten, Emmanuel B
KU Leuven

11:15-11:30 TuAT11.5
Liu, Xu
Shanghai Jiao Tong University

Wu, Baibo
Shanghai Jiao Tong University

Wu, Zhonghao
Shanghai Jiao Tong University

Zeng, Lingyun
Shanghai Jiao Tong University

Xu, Kai
Shanghai Jiao Tong University

10:45-11:00 TuAT12.1
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Chair: Mihalec, Marko
Rutgers University

Co-Chair: Solanki, Pratap
Michigan State University

Kim, Jehyeok  
Seoul National University

Moon, JunYoung  
ChungAng University

Kim, Jongwon  
Seoul National University

Lee, Giuk  
Chung-Ang University

Cam Profile Optimization of New Opposed Cam Engine Based on AHP Method, pp. 389-396.

Tang, Yuanjiang  
National University of Defense Technology

Xu, Xiaojun  
NUDT

Zhang, Lei  
National University of Defense Technology

Xu, Haijun  
NUDT

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Fan, Rujun  
Beihang University

Li, Yunhua  
Beihang University

Yang, Liman  
Beihang University


Rox, Margaret  
Vanderbilt University

Emerson, Maxwell  
Vanderbilt University

Ertop, Tayfun Efe  
Vanderbilt University

Fu, Mengyu  
University of North Carolina at Chapel Hill

Fried, Inbar  
University of North Carolina at Chapel Hill

Hoelscher, Janine  
UNC Chapel Hill

Kuntz, Alan  
University of Utah

Granna, Josephine  
Vanderbilt University

Mitchell, Jason  
Vanderbilt University

Lester, Michael  
Vanderbilt University Medical Center

Maldonado, Fabien  
Vanderbilt University

Gillaspie, Erin  
Vanderbilt University Medical Center

Akulian, Jason  
University of North Carolina at Chapel Hill

Alterovitz, Ron  
University of North Carolina at Chapel Hill

Webster III, Robert James  
Vanderbilt University


Riahi, Nayereh  
Southern Illinois University

Komaee, Arash  
Southern Illinois University, Carbondale

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zhang, sihan  
Zhejiang University
Zhu, Qiuguo  Zhejiang University
Wu, Jun  Zhejiang University
Xiong, Rong  Zhejiang University
Gu, Yong  College of Control Science and Engineering, Zhejiang University

10:15-10:45  TuP1S.5

Cardona, Diego  Galileo University
Maldonado Caballeros, Guillermo José  Galileo University
Fajardo, Julio  Universidad Galileo

10:15-10:45  TuP1S.6

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Vishway, Chitransh  Ryerson University
Hidru, Tsegai  Ryerson University
Sarkissian, Shawn  Ryerson University
Singarajah, Kavithan  Ryerson University
Zareinia, Kourosh  Ryerson University

10:15-10:45  TuP1S.7

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Moumneh, Alaa  Ryerson University
Asad, Ali  Ryerson University
Jamil, Umer  Ryerson University
Asaad, Syed  Ryerson University
Zareinia, Kourosh  Ryerson University

10:15-10:45  TuP1S.8

Digital Twin Technology to Optimize Parameters of the Remaining Useful Life of a Ball Bearing, pp. 422-426.
Nair, Sudev  Indian Institute of Technology Madras
Ramasamy, Iniyan  Indian Institute of Technology Madras
NS, Punyakoti  PES University

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Chair: Katsura, Seiichiro  Keio University
11:00-11:30  TuP2S.1

Arif, Asim  Ryerson University
Patel, Taral  Ryerson University
Shoaib, Taimur  Ryerson University
Zareinia, Kourosh  Ryerson University

11:00-11:30  TuP2S.2

Heidari, Omid  Idaho State University
Stone, Kenneth  Idaho State University
Chowdhury, Shovan  Idaho State University
Hedgepeth, Tyler  Idaho State University
Perez Gracia, Alba  Idaho State University
Schoen, Marco  Idaho State University
Dittrich, Shane  House of Design
Luna, Mike  The House of Design

11:00-11:30  TuP2S.3

Harapanahalli, Akash  Georgia Institute of Technology
Muly, Emil  Georgia Institute of Technology
Welch, Hogan  Georgia Institute of Technology
Brumfie1, Timothy  Georgia Institute of Technology
Weng, Zhengyang  Georgia Institute of Technology
Akhtar, Manzano  Georgia Institute of Technology
Abouelnasr, Ahmed  Georgia Institute of Technology
Newland, Austin  Georgia Institute of Technology
McGorrey, Kevin  Georgia Institute of Technology
Lee, Joo Shuen  Georgia Institute of Technology
Wang, Gaorong  Georgia Institute of Technology
Drnach, Luke  Georgia Institute of Technology
Lee, Dong Jae  Georgia Institute of Technology
Zhao, Ye  Georgia Institute of Technology

11:00-11:30  TuP2S.4

Online Torque Optimization of Wheeled Robots Based on a Multi Objective Algorithm, pp. 429-432.
Rosa, Diego  Pontifical Catholic University of Rio De Janeiro
Meggiolaro, Marco Antonio  Pontifical Catholic University of Rio De Janeiro
Martha, Luiz Fernando  Pontifical Catholic University of Rio De Janeiro (PUC-Rio)

11:00-11:30  TuP2S.5

Yang, Jun Yan  Waseda University, Graduate School of Information, Production An
Zhuang, Jyun Rong  Graduate School of Information, Production and Systems, Waseda U
Wu, Guan Yu  Graduate School of Information, Production and Systems, Waseda U
Tanaka, Eiichiro  Waseda University

11:00-11:30  TuP2S.6

Abdulhafiz, Ibrahim  Ryerson University
Janabi-Sharifi, Farrokh  Ryerson University
Zareinia, Kourosh  Ryerson University

11:00-11:30  TuP2S.7

Radial Coverage Strength for Optimization of Multi-Camera Deployment, pp. 429-429.
Lei, Zike  Wuhan University of Science and Technology
TuKT14 Room T13
Keynote Session 1 (Plenary Session)
Chair: Oldham, Kenn University of Michigan
11:40-12:20 TuKT14.1
Nonlinear Observer Design and Some Interesting Applications in Autonomous Systems*. Rajamani, Rajesh University of Minnesota
13:30-14:15 TuKT14.2
Adaptive Structures and Facades in Civil Engineering – a New Field for Intelligent Mechatronics*. Sawodny, Oliver University of Stuttgart
14:15-15:00 TuKT14.3
Towards Printing Mechatronics: 3D-Printed Conductive Interfacing for Digital Signals, pp. 430-435. Mazhari, Arash Alex University of California, Santa Cruz
14:30-15:15 TuKT14.4
A Robust Filtered Basis Functions Approach for Feedforward Tracking Control - with Application to a Vibration-Prone 3D Printer, pp. 436-444. Ramani, Kaval University of Michigan
15:15-16:00 TuKT14.5
Printing and Programming of In-Situ Actuators, pp. 445-450. Mazhari, Arash Alex University of California, Santa Cruz

TuBT1 Room T1
Mechatronics in 3D Printing (Regular Session)
Chair: Mazhari, Arash Alex University of California, Santa Cruz
Co-Chair: Popa, Andrei-Alexandru University of Southern Denmark
13:30-14:15 TuBT1.1
Jouffroy, Jerome University of Southern Denmark
Duggen, Lars University of Southern Denmark
13:45-14:00 TuBT1.2
A Robust Filtered Basis Functions Approach for Feedforward Tracking Control - with Application to a Vibration-Prone 3D Printer, pp. 436-444. Raman, Kaval University of Michigan
Edoimoiya, Nosakhare University of Michigan
Okwudire, Chinedum University of Michigan
14:00-14:15 TuBT1.3
Layer-To-Layer Predictive Control of Ink-Jet 3D Printing, pp. 451-459. Inyang-Udo, Uduak Rensselaer Polytechnic Institute
Guo, Yi Jie Rensselaer Polytechnic Institute
14:15-14:30 TuBT1.4

TuBT2 Room T2
Modeling and Control of Robots (Regular Session)
Chair: Shen, Yantao University of Nevada, Reno
Co-Chair: Koganezawa, Koichi Tokai University
13:30-13:45 TuBT2.1
Wire-Tension Feedback Control for Continuum Manipulator to Improve Load Manipulability Feature, pp. 460-465. Yeshmukhametov, Azamat Tokai University
Koganezawa, Koichi Tokai University
Seidakhmet, Askar Satpayev University
Yamamoto, Yoshio Tokai University
13:45-14:00 TuBT2.2
Modeling and Control of a Hybrid Wheeled Legged Robot: Disturbance Analysis, pp. 466-473. Raza, Fahad Tohoku University
Owaki, Dai Tohoku University
Hayashibe, Mitsuhiro Tohoku University
14:00-14:15 TuBT2.3
Guidance and Control Law Design for a Slung Payload in Autonomous Landing a Drone Delivery Case Study, pp. 474-481. Graham, Silas University of Toronto Institute for Aerospace Studies
Qian, Longhao University of Toronto Institute for Aerospace Studies
LIU, Hugh H.-T. University of Toronto
14:15-14:30 TuBT2.4
Spline-Based Modeling and Control of Soft Robots, pp. 482-487. Luo, Shuzhen Rutgers, the State University of New Jersey
Edmonds, Merrill Rutgers, the State University of New Jersey
Yi, Jingang Rutgers University
Zhao, Xianlian New Jersey Institute of Technology
Shen, Yantao University of Nevada, Reno
14:30-14:45 TuBT2.5
Depth-Based Visual Predictive Control of Tendon-Driven Continuum Robots, pp. 488-494. Fallah, Mostafa M.H. Ryerson University
Norouzi-Ghazbi, Somayeh Ryerson University
Mehrkish, Ali Ryerson University
Janabi-Sharifi, Farrokh Ryerson University

TuBT3 Room T3
Legged Robots II (Regular Session)
Chair: Bhounsule, Pranav University of Illinois at Chicago
Co-Chair: Yigit, Tank Rutgers University
13:30-13:45 TuBT3.1
### Analysis and Control of a Body-Attached Spring-Mass Runner Based on Central Pivot Point Approach

- Karagoz, Osman Kaan, Middle East Technical University
- Sever, Izet, Middle East Technical University
- Saranli, Uluc, Middle East Technical University
- ANKARALI, Mustafa Mert, Middle East Technical University

13:45-14:00 TuBT3.2

### Exploiting the SoC FPGA Capabilities in the Control Architecture of a Quadruped Robot

- Liu, Chao, Huazhong University of Science and Technology

14:00-14:15 TuBT3.3

### Thruster-Assisted Center Manifold Shaping in Bipedal Legged Locomotion

- Esslinger, Dominik, University of Stuttgart
- Oberdorfer, Martin, University of Stuttgart
- Kleckner, Laura, University of Stuttgart
- Sawodny, Oliver, University of Stuttgart
- Tarin, Cristina, University of Stuttgart

14:00-14:15 TuBT3.4

### An Arc-Shaped Rotating Magnet Solution for 3D Localisation of a Drug Delivery Capsule Robot

- Liu, Chih-Hsing, National Cheng Kung University
- Hsu, Mao-Cheng, NCKU
- Chen, Ta-Lun, National Cheng Kung University

14:00-14:15 TuBT3.5

### Recursive Bayesian Estimation Based Indoor Fire Location by Fusing Rotary UV Sensors

- Densborn, Simon, University of Stuttgart
- Sawodny, Oliver, University of Stuttgart

14:00-14:15 TuBT3.6

### Accurate LiDAR-Based Localization in Glass-Walled Environment

- Meng, Jie, Huazhong University of Science and Technology
- Wang, Shuting, Huazhong University of Science and Technology

14:00-14:15 TuBT3.7

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### Chair: Xie, Yuanlong

#### Localization (Regular Session)

- Chair: Xie, Yuanlong, Huazhong University of Science and Technology
- Co-Chair: Castano, Maria, Michigan State University

13:30-13:45 TuBT4.1

#### An Arc-Shaped Rotating Magnet Solution for 3D Localisation of a Drug Delivery Capsule Robot

- Valls Miro, Jaime, University of Technology Sydney
- Munoz, Fredy, University of Wollongong
- Miguel, Freyja Ivorie, University of Technology Sydney

13:45-14:00 TuBT4.2

#### Recursive Bayesian Estimation Based Indoor Fire Location by Fusing Rotary UV Sensors

- Kim, Jong-hwan, Korea Military Academy
- Moon, Sangwoo, Seoul National University

14:00-14:15 TuBT4.3

#### Accurate LiDAR-Based Localization in Glass-Walled Environment

- Meng, Jie, Huazhong University of Science and Technology
- Wang, Shuting, Huazhong University of Science and Technology

14:00-14:15 TuBT4.4

#### Receiver Self-Localization for an Opto-Acoustic and Inertial Indoor Localization System

- Esslinger, Dominik, University of Stuttgart
- Oberdorfer, Martin, University of Stuttgart
- Kleckner, Laura, University of Stuttgart
- Sawodny, Oliver, University of Stuttgart
- Tarin, Cristina, University of Stuttgart

14:30-14:45 TuBT4.5

#### A Geometry-Aware Hidden Markov Model for Indoor Positioning

- Rudic, Branislav, Linz Center of Mechatronics GmbH
- Pichler-Scheder, Markus, Linz Center of Mechatronics GmbH
- Schmidt, Richard, Linz Center of Mechatronics GmbH
- Helmel, Christian, Linz Center of Mechatronics GmbH
- Efrosinin, Dmitry, Johannes Kepler University
- Kastl, Christian, Linz Center of Mechatronics GmbH
- Auer, Wolfgang, AISEMO GmbH

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### Chair: Zhu, Guoming George

#### Compliant Structures and Mechanisms (Regular Session)

13:30-13:45 TuBT5.1

#### Topology and Geometry Optimization for Design of a 3D Printed Compliant Constant-Force Mechanism

- Liu, Chih-Hsing, National Cheng Kung University
- Hsu, Mao-Cheng, NCKU
- Chen, Ta-Lun, National Cheng Kung University

13:45-14:00 TuBT5.2

#### Closed-Form Solutions and Analysis of the Eigenmodes of Euler-Bernoulli Beams with Inner Pinned Support and End Mass

- Densborn, Simon, University of Stuttgart
- Sawodny, Oliver, University of Stuttgart

14:00-14:15 TuBT5.3

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14:15-14:30 TuBT5.4
Shape Memory Effect of Benchmark Compliant Mechanisms Designed with Topology Optimization, pp. 571-576.
Thabuis, Adrien Ecole Polytechnique Fédérale De Lausanne (EPFL)
Thomas, Sean Ecole Polytechnique Fédérale De Lausanne (EPFL)
Martinez, Thomas Ecole Polytechnique Fédérale De Lausanne (EPFL)
Perriard, Yves Ecole Polytechnique Fédérale De Lausanne (EPFL)

14:30-14:45 TuBT5.5
Optimal Sensor Placement for Flexible Wings Using the Greedy Algorithm, pp. 577-582.
HE, TIANYI Michigan State University
Zhu, Guoming George Michigan State University
Swei, Sean NASA Ames Research Center
Su, Weihua University of Alabama

TuBT6 Room T6
Grasping (Regular Session)
Chair: Shimono, Tomoyuki Yokohama National University
Co-Chair: Zhang, Tong University of Windsor

13:30-13:45 TuBT6.1
A 3D Printed Modular Soft Gripper for Conformal Grasping, pp. 583-588.
Tawk, Charbel University of Wollongong
Mutlu, Rahim University of Wollongong
Alici, Gursel University of Wollongong

13:45-14:00 TuBT6.2
Rigid Grasp Candidate Generation for Assembly Tasks, pp. 589-594.
Park, Suhan Seoul National University
baek, jieyong Seoul National University
Kim, Seungyeon Graduate School of Convergence Science and Technology, Seoul Nat
Park, Jaeheung Seoul National University

14:00-14:15 TuBT6.3
Yajima, Shotaro Yokohama National University
Shimono, Tomoyuki Yokohama National University
Mizoguchi, Takahiro Kanagawa Academy of Science and Technology
Ohnishi, Kouhei Keio Univ

14:15-14:30 TuBT6.4
Wang, Chi-Heng National Taiwan University
Lin, Pei-Chun National Taiwan University

14:30-14:45 TuBT6.5
Suction Cup Based on Particle Jamming and Its Performance Comparison in Various Fruit Handling Tasks, pp. 607-612.
Gilday, Kieran University of Cambridge
Lilley, James University of Cambridge
Iida, Fumiya University of Cambridge

TuBT7 Room T7
Control of Robotic Manipulators II (Regular Session)
Chair: Ueda, Jun Georgia Institute of Technology
Co-Chair: Lei, Zike University of Windsor

13:30-13:45 TuBT7.1
Encrypted Feedback Linearization and Motion Control for Manipulator with Somewhat Homomorphic Encryption, pp. 613-618.
Teranishi, Kaoru The University of Electro-Communications
Kogiso, Kiminao The University of Electro-Communications
Ueda, Jun Georgia Institute of Technology

13:45-14:00 TuBT7.2
Lampinen, Santeri Tampere University
Niemi, Jouni RamBooms Oy
Mattila, Jouni Tampere University of Technology

14:00-14:15 TuBT7.3
Flow-Limited Path-Following Control of a Double Ackermann Steered Hydraulic Mobile Manipulator, pp. 625-630.
Hulltinen, Lionel Tampere University
Mattila, Jouni Tampere University of Technology

14:15-14:30 TuBT7.4
Galarza Panimboza, Juan Universidad De Las Fuerzas Daniel Universidad De Las Fuerzas
Escobar Carvajal, Luis Armadas ESPE
Fernando Armadas ESPE
Loza Matovelle, David César Universidad De La Fuerzas

TuBT8 Room T8
Mechatronic Applications in Automotive Systems (Invited Session)
Chair: Shim, Taehyun University of Michigan - Dearborn
Co-Chair: Langari, Reza Texas A&M University
Organizer: Chen, Yan Arizona State University
Organizer: Shahbakhti, Mahdi University of Alberta
Organizer: Shim, Taehyun University of Michigan - Dearborn
Organizer: wang, Yan Ford Motor Company
Organizer: Zeng, Xiangrui Worcester Polytechnic Institute

13:30-13:45 TuBT8.1
Model-Based Knock Prediction and Its Stochastic Feedforward Compensation (I), pp. 637-642.
Li, Ruixue Mathworks
Zhu, Guoming George Michigan State University


**Li, Yijun**  
University of Michigan-Dearborn

**Shim, Taehyun**  
University of Michigan - Dearborn

**Shin, Dong-Hwan**  
DGIST(Daegu Gyeongbuk Institute of Science & Technology)

**Lee, Seonghun**  
DGIST

**jin, sungho**  
Daegu Gyeongbuk Institute of Science & Technology

### Shared Control between Human Driver and Machine Based on Game Theoretical Model Predictive Control Framework (I), pp. 649-654.

**Ko, Sangjin**  
Texas A&M University

**Langari, Reza**  
Texas A&M University

### Turbocharger Waste Gate Sensitivity Based Adaptive Control (I), pp. 655-662.

**Kokotovic, Vladimir**  
Ford Research Innovation Center

**Zhang, Xiaogang**  
Ford Motor Company

### Human-Machine Interface II (Regular Session)

**Chair:** Tavakoli, Mahdi  
University of Alberta

**Co-Chair:** Winck, Ryder  
Rose-Hulman Institute of Technology

#### Assessing Meditation State Using EEG-Based Permutation Entropy Features (I), pp. 663-666.

**Han, Yupeng**  
South China University of Technology

**Huang, Weichen**  
South China University of Technology

**Huang, Haiyun**  
South China University of Technology

**Jing, Xiao**  
South China University of Technology

**Li, Yuanqing**  
South China University of Technology

### Machine Vision II (Regular Session)

**Chair:** Ji, Jingjing  
Huazhong University of Science and Technology

**Co-Chair:** Huang, Yang  
Guilin University of Electronic Technology

#### Approximation of Covariance Matrices Based on Matching Accuracy, pp. 691-696.

**Rupp, Martin Tobias Michael**  
University of Stuttgart

**Blagojevic, Boris**  
University Stuttgart

**Knoll, Christian**  
Robert Bosch GmbH

**Zapf, Marc Patrick Hans**  
Bosch (China) Investment Co., Ltd

**Zhang, Weimin**  
Tongji University

**Sawodny, Oliver**  
University of Stuttgart


**André, Antoine N.**  
Femto-St

**Sandoz, Patrick**  
FEMTO-ST Institute - CNRS UMR 6174

**Mauzé, Benjamin**  
University Bourgogne Franche-Comté, Femto-ST Institute ASM Depar

**JACQUOT, Maxime**  
FEMTO-ST Institute - Université Bourgogne Franche-Comté

**Laurent, Guillaume J.**  
Univ. Bourgogne Franche-Comté, ENSMIM

#### Digital Image Correlation Based on Primary Shear Band Model for Reconstructing Displacement, Strain and Stress Fields in Orthogonal Cutting, pp. 706-716.

**Huang, Yang**  
Guilin University of Electronic Technology

**Lee, Kok-Meng**  
Georgia Institute of Technology

TuBT11
Medical Mechatronics II (Regular Session)

Chair: Atashzar, S. Farokh New York University (NYU), US
Co-Chair: Trkov, Mitja Rowan University

13:30-13:45 TuBT11.1
A New Electromagnetic Actuation System with a Highly Accessible Workspace for Microrobot Manipulation, pp. 723-728.

CHAH, Ahmed Artedrone Company / HEI Campus Centre
KROUBI, Tarik University Mouloud Mammeri of Tizi-Ouzou, Algeria & HEI Campus Centre
Belharet, Karim Hautes Etudes d'Ingénieur - HEI Campus Centre

13:45-14:00 TuBT11.2

Haque, Md Rejwanul The University of Alabama
Shen, Xiangrong The University of Alabama

14:00-14:15 TuBT11.3
Compressed Gas Actuated Knee Assistive Exoskeleton for Slip-Induced Fall Prevention During Human Walking, pp. 735-740.

Mioskowska, Monika Rowan University
Stevenson, Duncan Rowan University
Onu, Michael Rowan University
Trkov, Mitja Rowan University

14:15-14:30 TuBT11.4

Faieghi, Reza Toronto Rehabilitation Institute
Atashzar, S. Farokh New York University (NYU), US
Sharma, Mayank Western University
Tutunea-Fatan, O. Remus Western University
Eagleson, Roy University of Western Ontario
Ferreira, Louis Western University

TuBT12
Humanoid Robots (Regular Session)

Chair: Zhao, Ye Georgia Institute of Technology
Co-Chair: Padir, Taskin Northeastern University

13:30-13:45 TuBT12.1
Generation of Human-Like Gait Adapted to Environment Based on a Kinematic Model, pp. 747-752.
### Technical Program for Wednesday July 8, 2020

#### WePL

**Plenary Session 2 (Plenary Session)**

**Chair:** Tan, Xiaobo  
**Room T13**

09:00-10:00  

**WePL.1**

*Soft Robotics: From Bioinspiration to New Mechatronic Technologies for Further Robotics Application Scenarios*.

Laschi, Cecilia  
Scuola Superiore Sant'Anna

#### WeAT1

**Room T1**

**Novel Smart Material Actuators (Regular Session)**

**Chair:** Mansour, Nader A.  
**Co-Chair:** Wang, Yu-Jen  
Hanbat National University  
National Sun Yat-Sen University

10:15-10:30  

**WeAT1.1**

*Development of a Vacuum Suction Cup by Applying Magnetorheological Elastomers for Objects with Flat Surfaces*, pp. 777-782.

Zhang, Peizhi  
Waseda University

Kamezaki, Mitsuhiro  
Waseda University

Otsuki, Kenshiro  
Waseda University

He, Zhuoyi  
Waseda University

Sakamoto, Hiroyuki  
Waseda University

Sugano, Shigeki  
Waseda University

10:30-10:45  

**WeAT1.2**

*ANFIS-Based System Identification and Control of a Compliant Shape Memory Alloy (SMA) Rotating Actuator*, pp. 783-788.

Mansour, Nader A.  
Hanbat National University

BAEK, Hangyeol  
Hanbat National University

Jang, Taesoo  
Hanbat National University

Shin, Bu Hyun  
Hanbat National University

Kim, Youngshik  
Hanbat National University

10:45-11:00  

**WeAT1.3**

*A Driving Distance Extended Piezoelectric Actuator Using Multidriving Pads and Capacitive Patches*, pp. 789-794.

Ho, Jie-Lin  
National Sun Yat-Sen University

Wang, Yu-Jen  
National Sun Yat-Sen University

Jiang, Yi-Bin  
National Sun Yat-Sen University

11:00-11:15  

**WeAT1.4**

*Multi-Output Compliant Shape Memory Alloy Bias-Spring Actuators*, pp. 795-800.

Thomas, Sean  
Ecole Polytechnique Fédérale De Lausanne (EPFL)

Thabuis, Adrien  
Ecole Polytechnique Fédérale De Lausanne (EPFL)

Martinez, Thomas  
Ecole Polytechnique Fédérale De Lausanne (EPFL)

Perriard, Yves  
Ecole Polytechnique Fédérale De Lausanne (EPFL)

#### WeAT2

**Room T2**

**Modeling and Design of Mechatronic Systems I (Regular Session)**

**Chair:** Foong, Shaohui  
**Co-Chair:** ISHII, Hiroyuki  
Singapore University of Technology and Design  
Waseda University

10:15-10:30  

**WeAT2.1**


Satake, Yuki  
Waseda University

Takanishi, Atsuo  
Waseda University

ISHII, Hiroyuki  
Waseda University

10:30-10:45  

**WeAT2.2**

*Key Characteristics Analysis of Vibration Isolator Used in High Precision Testing Equipment*, pp. 810-817.

Liu, Chengyao  
Beihang University

Li, Wanguo  
Beihang University

Chen, Jianming  
Beihang University

10:45-11:00  

**WeAT2.3**

*Design and Validation of a Novel Leaf Spring Based Variable Stiffness Joint with Reconfigurability*, pp. 818-825.

Wu, Jiahao  
The Chinese University of Hong Kong

Wang, Zerui  
The Chinese University of Hong Kong

CHEN, Wei  
The Chinese University of Hong Kong

Wang, Yaqing  
The Chinese University of Hong Kong

Liu, Yunhui  
The Chinese University of Hong Kong

11:00-11:15  

**WeAT2.4**


Chen, Hu  
National University of Defense Technology

Hou, Qingkai  
National University of Defense Technology

Xu, Haijun  
NUDT

Zhang, Lei  
National University of Defense Technology

11:15-11:30  

**WeAT2.5**


LEE, SHAWNDY MICHAEL  
Singapore University of Technology and Design

Chien, Jer Luen  
Singapore University of Technology & Design

Tang, Emmanuel  
Singapore University of Technology & Design

Lee, Denzel  
Singapore University of Technology and Design

Liu, Jingmin  
Singapore University of Technology & Design

Lim, Ryan Jon Hui  
Singapore University of Technology & Design

Foong, Shao Hui  
Singapore University of Technology and Design

#### WeAT3

**Room T3**
Aerial Robots I (Regular Session)

Chair: Son, Hungsun  Ulsan National Institute of Science and Technology
Co-Chair: Abiko, Satoko  Shibaura Institute of Technology

10:15-10:30  WeAT3.1

Seamless 90-Degree Attitude Transition Flight of a Quad Tilt-Rotor UAV under Full Position Control, pp. 839-844.
Magariyama, Tomoyuki  Shibaura Institute of Technology
Abiko, Satoko  Shibaura Institute of Technology

10:30-10:45  WeAT3.2

Thruster Allocation and Mapping of Aerial and Aquatic Modes for a Morphable Multimodal Quadrotor, pp. 845-854.
Tan, Yu Herng  National University of Singapore
Chen, Ben M.  Chinese University of Hong Kong

10:45-11:00  WeAT3.3

Win, Shane Kyi Hla  Singapore University of Technology & Design
Win, Luke Soe Thura  Singapore University of Technology & Design
Sufiyan, Danial  Singapore University of Technology & Design
Soh, Gim Song  Singapore University of Technology & Design
Foong, Shaohui  Singapore University of Technology & Design

11:00-11:15  WeAT3.4

Design and Control of Multibody Multirotor for Faster Flight and Manipulation, pp. 862-867.
Chung, Wonmo  UNIST
Son, Hungsun  Ulsan National Institute of Science and Technology

11:15-11:30  WeAT3.5

Generation and Control of Impulsive Forces by a Planar Bi-Rotor Aerial Vehicle through a Cable Suspended Mass, pp. 868-873.
Jain, Prakhar  Indian Institute of Technology Bombay
Sangwan, Vivek  Indian Institute of Technology Bombay

Mobile Robots II (Regular Session)

Chair: Xie, Yuanlong  Huazhong University of Science and Technology
Co-Chair: Okui, Manabu  Chuo University

10:15-10:30  WeAT4.1

Proposal for Pipeline-Shape Measurement Method Based on Highly Accurate Pipeline Length Measurement by IMU Sensor Using Peristaltic Motion Characteristics, pp. 874-881.
Sato, Hirotasu  Chuo University
Mano, Yuki  Chuo-University
Ito, Fumio  Chuo University
Yasui, Takumi  Chuo University
Okui, Manabu  Chuo University
Nishihama, Rie  Chuo University
Nakamura, Taro  Chuo University

10:30-10:45  WeAT4.2

Iqbal, Amir  University of Massachusetts, Lowell, MA
Gao, Yuan  UMass Lowell
Gu, Yan  UMass Lowell

10:45-11:00  WeAT4.3

Inverse Decoupling-Based Direct Yaw Moment Control of a Four-Wheel Independent Steering Mobile Robot, pp. 892-897.
Jiang, Liquan  Huazhong University of Science and Technology
Wang, Shuling  Huazhong University of Science and Technology
Meng, Jie  Huazhong University of Science and Technology
Zhang, Xiaolong  Huazhong University of Science and Technology
Jin, Jian  Huazhong University of Science and Technology
Xie, Yuanlong  Huazhong University of Science and Technology

11:00-11:15  WeAT4.4

Li, Chih-Hung G.  National Taipei University of Technology
Zhou, Long-Ping  National Taipei University of Technology

11:15-11:30  WeAT4.5

Reaction-Wheel-Based Roll Stabilization for a Robotic Fish Using Neural Network Sliding Mode Control, pp. 904-909.
Zhang, Pengfei  Institute of Automation, Chinese Academy of Sciences
Wu, Zhengxing  Chinese Academy of Sciences
Dong, Huijie  Institute of Automation, Chinese Academy of Sciences
Tan, Min  Institute of Automation, Chinese Academy of Sciences
Yu, Junzhi  Chinese Academy of Sciences

Room T4

WeAT4
### Soft Mechatronics II (Regular Session)

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<tr>
<td>10:15-10:30</td>
<td>Elastic Actuator Safety Improvement in the Turning Motion Using the Series and Parallel Elastic Actuators</td>
<td>WeAT5.1</td>
</tr>
<tr>
<td>10:30-10:45</td>
<td>Modelling and Simulation of Pneumatic Sources for Soft Robotic Applications</td>
<td>WeAT5.2</td>
</tr>
<tr>
<td>10:45-11:00</td>
<td>3D Printed Soft Pneumatic Bending Sensing Chambers for Bilateral and Remote Control of Soft Robotic Systems</td>
<td>WeAT5.3</td>
</tr>
<tr>
<td>11:00-11:15</td>
<td>Drop Impact Analysis and Shock Absorbing Motion of a Life-Sized One-Legged Robot with Soft Outer Shells and a Flexible Joint</td>
<td>WeAT5.4</td>
</tr>
<tr>
<td>11:15-11:30</td>
<td>Toward Vision-Based Adaptive Configuring of a Bidirectional Two-Segment Soft Continuum Manipulator</td>
<td>WeAT5.5</td>
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### WeAT6 Series and Parallel Elastic Actuators (Regular Session)

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Room</th>
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<tbody>
<tr>
<td>10:15-10:30</td>
<td>Safety Improvement in the Turning Motion Using the Series Elastic Actuator</td>
<td>WeAT6.1</td>
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<tr>
<td>10:30-10:45</td>
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<td>WeAT6.2</td>
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### WeAT7 Robotic Manipulators I (Regular Session)

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Zhang, Jingyi Tianjin University
Li, Wei Tianjin University
Ma, Shugen Ritsumeikan University

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Co-Chair: Wang, Yafei Shanghai Jiaotong University

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Yin, Guodong Southeast University
Ren, Yanjun Southeast University
Wang, Jinxian Southeast University
Li, Jinbo Southeast University
Sha, Wenhao Southeast University

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Wang, Yafei Shanghai Jiaotong University
Hu, Jia-Sheng National University of Tainan
Nam, Kanghyun Yeungnam University
Yin, Chengliang School of Mechanical Engineering, Shanghai Jiao Tong University

10:45-11:00 **WeAT8.2**

Wang, Yan Southeast University
Zhang, Fengjiao Changzhou Vocational Institute of Mechatronic Technology
Geng, Keke Southeast University
Zhuang, Weichao Southeast University
Dong, Haoxuan Southeast University
Yin, Guodong Southeast University

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Homann, Andreas TU Dortmund University
Buss, Markus ZF Group
Keller, Martin ZF Group
Bertram, Torsten Technische Universität Dortmund

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Arab, Aalasghar Rutgers University
Yi, Jingang Rutgers University

**Bio-Inspired Actuators and Robots (Regular Session)**
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Co-Chair: Chen, Siyu Rutgers University

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Mostashiri, Naser The University of Auckland
Dhupia, Jaspreet The University of Auckland
Verl, Alexander University of Stuttgart
Xu, Weiliang The University of Auckland

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Machida, Katsuki Chuo University
Kimura, Seigo Chuo University
Suzuki, Ryuji Chuo University
yokoyama, kazuya Solaris Ink
Okui, Manabu Chuo University
Nakamura, Taro Chuo University

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Matsui, Daisuke Chuo University
Wakamatsu, Kota Chuo University
Hagiwara, Daiki Chuo University
Ueda, Masahiro TAKENAKA CORPORATION
Yamada, Yasuyuki HOSEI University
Nakamura, Taro Chuo University

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Mateos, Luis MIT
Guzman, Luis UBTECH

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Yang, Weixin University of Nevada, Reno
Yi, Jingang Rutgers University

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Dinh, Tran Hiep VNU University of Engineering and Technology, Vietnam National University
Le, Ha Vu VNU University of Engineering and Technology
Zhu, Qiuchen University of Technology, Sydney
Ha, Q P University of Technology Sydney

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WANG, Shaoping Beihang University
Shi, Jian Beihang University

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Haas, Rainer Linz Center of Mechatronics
Putz, Veronika Linz Center of Mechatronics
Kastl, Christian Linz Center of Mechatronics

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Terra, Marco Henrique University of Sao Paulo
Krebs, Hermano Igo MIT

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Li, Yisong Zhejiang University

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Chen, Kuo Rutgers University
YU, JIAJING Rutgers University
Yi, Jingang Rutgers University

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Yi, Jingang Rutgers University

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Jelvani, Alborz Rutgers University
Edmonds, Merrill Rutgers, the State University of New Jersey
Gong, Yongbin Rutgers, the State University of New Jersey
Yi, Jingang Rutgers University

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Burunchina, Karina Nazarbayev University
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Belharet, Karim Hautes Etudes d'Ingénieur - HEI Campus Centre
GUECHI, Elhadi Automatic Laboratory of Skikda

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Li, Yao Nanjing University of Aeronautics and Astronautics
Kang, Shengzheng Nanjing University of Aeronautics & Astronautics
Chen, Bai Nanjing University of Aeronautics and Astronautics
Lu, Huimin Kyushu Institute of Technology
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Ji, Ping The Hong Kong Polytechnic University

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amiri, parviz Associate Professor of Electrical Engineering, Shahid Rajaee Tea

WeBT3.3 Fault Tolerance Analysis for a Class of Reconfigurable Hexarotor Vehicles, pp. 1262-1269.
Pose, Claudio Daniel Facultad De Ingenieria - Universidad De Buenos Aires
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WeBT3.4 Ground Trajectory Control of an Unmanned Aerial-Ground Vehicle Using Thrust Vectoring for Precise Grasping, pp. 1270-1275.
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Patnaik, Karishma Arizona State University
Garrard, Yizhuang Arizona State University
Chase, Zachary Arizona State University
Plough, Michael Salt River Project, Tempe
Zhang, Wenlong Arizona State University

WeBT3.5 Control of Multiple Quad-Copters with a Cable-Suspended Payload Subject to Disturbances, pp. 1276-1285.
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Siroospour, Shahin McMaster University
Grivani, Ali McMaster University

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Wan, Hongyu  Ningbo Institute of Materials Technology and Engineering, China
Chen, Silu  Ningbo Institute of Material Technology and Engineering, Chinese
Liu, Yisha  Hebei University of Science and Technology
Jin, Chaoshao  Ningbo Welllh Robot Technology Co., Ltd
Chen, Furu  Ningbo Welllh Robot Technology Co., Ltd
Wang, Jia  Zhejiang University
Zhang, Chi  Ningbo Institute of Material Technology and Engineering, CAS
Yang, Guilin  Ningbo Institute of Material Technology and Engineering, China

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Huo, Zixuan  Nankai University
Dai, Shilong  Nankai University
Yuan, Mingxing  Nankai University
Chen, Xiaoyan  University of Windsor
Zhang, Xuebo  Nankai University

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Chen, Zheng  Zhejiang University
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Yuan, Chengzh  University of Rhode Island

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Sandibay, Nazerke  Nazarbayev University
Rakhim, Bexultan  Nazarbayev University
Varol, Huseyin Atakan  Nazarbayev University
Rubagotti, Matteo  Nazarbayev University

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Lindstahl, Simon  Ericsson
Lan, Xiaoyu  Ericsson

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Jeon, Soo  University of Waterloo
Choi, Jongeun  Yonsei University

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Co-Chair: Zhang, Tong  University of Windsor

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Wu, Hongtao  Nanjing University of Aeronautics and Astronautics
Yu, Shengdong  Nanjing University of Aeronautics and Astronautics
Li, Yao  Nanjing University of Aeronautics and Astronautics
Yang, Xiaolong  The City University of New York, City College
Yao, Jiafeng  Nanjing University of Aeronautics and Astronautics

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Sawodny, Oliver University of Stuttgart

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Li, Zhigui Harbin Institute of Technology
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Mustalahti, Pauli Tampere University
Launis, Sirpa Sandvik Mining and Construction Oy
Mattila, Jouni Tampere University of Technology


Islam, Shafiqul Xavier University of Louisiana
Ali Khawli, Toufik RWTH Aachen University

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Moualeu, Antonio Georgia Institute of Technology Pluckter, Kevin Carnegie Mellon University Ueda, Jun Georgia Institute of Technology

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Itani, Omar American University of Beirut Shammas, Elie American University of Beirut

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Fu, Han University of Toronto LIU, Hugh H.-T. University of Toronto

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14:15-14:30 WaBT10.4
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Li, Min Minnesota State University Ammanabrolu, Jayanth Minnesota State University, Mankato

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Fries, Terrence Indiana University of Pennsylvania

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Tan, Chee How Singapore University of Technology & Design Sufiyan, Daniel Singapore University of Technology & Design Tang, Emmanuel Singapore University of Technology & Design Soh, Gim Song Singapore University of Technology & Design Foong, Shaohui Singapore University of Technology & Design

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Hasan, Agus University of Southern Denmark

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Wei, Wengeng Michigan State University Dourra, Hussein Magna International Zhu, Guoming George Michigan State University

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Fan, Miaolin Northeastern University
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|            |                                                                       | University of Michigan  
Universidad Galileo                                                         |
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Maldonado Caballeros, Guillermo José  
Ribas Neto, Antonio  
Rohmer, Eric                                                      |
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State University of Campinas - UNICAMP                                      |
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University of Michigan                                                     |
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Yoon, Se Young (Pablo)                                                     |
|            |                                                                       | University of New Hampshire  
University of New Hampshire                                                     |
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| Co-Chair: Tsuji, Toshiaki | Saitama University |
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| Sakaino, Sho | University of Tsukuba |
| Tsuji, Toshiaki | Saitama University |
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| *Suppression of Torque Ripple Caused by Misalignment of the Gearbox by Using Harmonic Current Injection Method*, pp. 1579-1588. | | |
| Park, Soo-Hwan | Hanyang University |
| PARK, JIN-CHEOL | Hanyang |
| HWANG, SUNG-WOO | Hanyang University |
| Kim, Jae-Hyun | Department of Automotive Engineering, Hanyang University |
| Park, Hyeonjin | Korea Automotive Technology Institute |
| Lim, Myung-Seop | Hanyang University |
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| Galimzhanov, Temirfan | Nazarbayev University |
| Zhukatayev, Altay | Nazarbayev University |
| Kashapov, Ramil | Kazan Federal University |
| Kappassov, Zhanat | Pierre and Marie Curie University |
| Varol, Huseyin Atakan | Nazarbayev University |
| **11:45-12:00** | ThAT1.4 |
| Böhm, Michael | University of Stuttgart |
| Wagner, Julia Laura | University of Stuttgart |
| Steffen, Simon | University of Stuttgart |
| Gade, Jan | University of Stuttgart |
| Geiger, Florian | University of Stuttgart |
| Sobek, Werner | University of Stuttgart |
| Bischoff, Manfred | University of Stuttgart |
| Sawodny, Oliver | University of Stuttgart |

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| **Modeling and Design of Mechatronic Systems II** (Regular Session) |
| Chair: Schitter, Georg | Vienna University of Technology |
| Co-Chair: Solanki, Pratap | Michigan State University |
| **11:00-11:15** | ThAT2.1 |
| *Switching Controller-Less Approach and Contact Controls Based on Force Impulse Regulator*, pp. 1601-1606. | | |
| Kawai, Yusuhe | Nagaoka University of Technology |
| Yokokura, Yuki | Nagaoka University of Technology |
| Ohishi, Kiyoshi | Nagaoka University of Technology |
| Miyazaki, Toshima | Nagaoka University of Technology |
| **11:15-11:30** | ThAT2.2 |
| *Design of a Mechanical Tunable Resonant Fast Steering Mirror*, pp. 1607-1612. | | |
| Schlarp, Johannes | Vienna University of Technology |
| Csenics, Ernst | Vienna University of Technology |
| Doblinger, Gabriel | Doma Elektro Engineering GmbH |
| Schitter, Georg | Vienna University of Technology |
| **11:30-11:45** | ThAT2.3 |
| Suzuki, Masaya | Shibaura Institute of Technology |
| Abiko, Satoko | Shibaura Institute of Technology |
| Tsujita, Teppei | National Defense Academy of Japan |
| Abe, Koyu | Allsafe Japan LTD |
| **11:45-12:00** | ThAT2.4 |
| *How to Get a Parcel Surfing*, pp. 1619-1624. | | |
| Westbrink, Fabian | South Westphalia University of Applied Sciences Soest |
| Schwung, Andreas | South Westfalia University of Applied Sciences |
| Ding, Steven X. | University of Duisburg-Essen |

| **ThAT3** | Room T3 |
| **Control of Unmanned Aerial Vehicles** (Regular Session) |
| Chair: Foong, Shaohui | Singapore University of Technology and Design |
| Co-Chair: Zhang, Xuebo | Nankai University, |
| **11:00-11:15** | ThAT3.1 |
| *Achieving Efficient Controlled Flight with a Single Actuator*, pp. 1625-1631. | | |
| Win, Luke Soe Thura | Singapore University of Technology and Design |
| Win, Shane Kyl Hla | Singapore University of Technology and Design |
| Sufiyan, Danial | Singapore University of Technology and Design |
| Soh, Gim Song | Singapore University of Technology and Design |
| Foong, Shaohui | Singapore University of Technology and Design |
| **11:15-11:30** | ThAT3.2 |

Sufiyan, Danial
Singapore University of Technology & Design

Pheh, Ying Hong
Singapore University of Technology & Design

Win, Luke Soe Thura
Singapore University of Technology & Design

Win, Shane Kyi Hla
Singapore University of Technology & Design

Soh, Gim Song
Singapore University of Technology and Design

Foong, Shaohui
Singapore University of Technology and Design

Reinforcement Learning Control for Multi-Axis Rotor Configuration UAV, pp. 1648-1653.

Dai, Yi-Wei
National Chiao Tung University

Pi, Chen-Huan
National Chiao Tung University

Hu, Kai-Chun
National Chiao Tung University

Cheng, Stone
National Chiao Tung University

Fuzzy Adaptive Sliding Mode Control for Unmanned Quadrotor Helicopter, pp. 1654-1658.

Xie, Yuanlong
University of Electronic Science and Technology of China

Xiong, Caihua
Huazhong University of Science and Technology

Adaptive Proxy-Based Robust Control Integrated with Nonlinear Disturbance Observer for Pneumatic Muscle Actuators, pp. 1692-1699.

Wu, Dongrui
Huazhong University of Science and Technology

Chen, Xiang
Cardiff University

Cao, Yu
Huazhong University of Science and Technology

Huang, Jian
Huazhong University of Science and Technology

Xiong, Caihua
Huazhong University of Science & Tech

Zhang, Mengshi
Huazhong University of Science and Technology

Li, Zhijun
University of Science and Technology of China

Hasegawa, Yasushisa
Nagoya University

Online Collision Avoidance for Human-Robot Collaborative Interaction Concerning Safety and Efficiency, pp. 1667-1672.

Liu, Guoliang
Shandong University

He, Haoyang
Shandong University

Tian, Guohui
Shandong University

Zhang, Jianhua
Hebei University of Technology

Ji, Ze
Cardiff University

Modular ROS Based Autonomous Mobile Industrial Robot System for Automated Intelligent Manufacturing Applications, pp. 1673-1678.

Luo, Ren
National Taiwan University

Lee, Shang Lun
National Taiwan University

Wen, Yu Cheng
Department of Electrical Engineering, National Taiwan University

Hsu, Chin Hao
National Taiwan University


Castano, Maria
Michigan State University

Hess, Andrew
Michigan State University

Mamakoukas, Giorgos
Northwestern University

Gao, Tong(Tony)
Michigan State University

Murphey, Todd
Northwestern University

Tan, XiaoBo
Michigan State University

Adaptive Proxy-Based Robust Control Integrated with Nonlinear Disturbance Observer for Pneumatic Muscle Actuators, pp. 1692-1699.

Cao, Yu
Huazhong University of Science and Technology

Huang, Jian
Huazhong University of Science and Technology

Xiong, Caihua
Huazhong University of Science & Tech

Wu, Dongrui
Huazhong University of Science and Technology

Zhang, Mengshi
Huazhong University of Science and Technology

Li, Zhijun
University of Science and Technology of China

Hasegawa, Yasushisa
Nagoya University

MISO Model Free Adaptive Control of Single Joint Rehabilitation Robot Driven by Pneumatic Artificial Muscles, pp. 1700-1705.

Li, Yi
Wuhan University of Technology

Liu, Quan
Wuhan University of Technology

Meng, Wei
Wuhan University of Technology

Xie, Yuanlong
Huazhong University of Science and Technology

Ai, Qingsong
Wuhan University of Technology

Xie, Shane
University of Leeds

Xie, Zhexin
Beihang University
yuan, feiyang
Beihang University
liu, zemin
Beihang University
sun, zhaoning
Beihang University
Kreibben, Elias M.
Festo AG & Co. KG
Wen, Li
Beihang University

12:00-12:15 ThAT5.5
Self-Sensing of Dielectric Tubular Actuator and Its Validation in Feedback Control, pp. 1712-1717.

Wang, Shengbin
University of Houston
Kaaya, Theophilus
University of Houston
Chen, Zheng
University of Houston

ThAT6 Room T6
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Chair: Islam, Shafiqul
Xavier University of Louisiana
Co-Chair: Matsuhira, Nobuto
Shibaura Institute of Technology

11:00-11:15 ThAT6.1
Multilateral Haptic Feedback Control by Transmission of Force Information, pp. 1718-1723.

Nagatsuka, Yuki
Chuo University
Hashimoto, Hideki
Chuo University

11:15-11:30 ThAT6.2
Distance Control between an Object and an End Effector for Contactless Surface Tracking Works by a Humanoid Robot, pp. 1724-1729.

Matsushima, Shunsuke
National Defense Academy of Japan
Tsujita, Teppei
National Defense Academy of Japan
Abiko, Satoko
Shibaura Institute of Technology

11:30-11:45 ThAT6.3
Flexible Remote-Controlled Robot System with Multiple Sensor Clients Using a Common Network Communication Protocol, pp. 1730-1735.

Satoru, Miki
Shibaura Institute of Technology
Nishioka, Takuya
Shibaura Institute of Technology
Hyuga, Sekiya
Shibaura Institute of Technology
Matsuhira, Nobuto
Shibaura Institute of Technology

11:45-12:00 ThAT6.4
Adaptive Robust Control of Bilateral Teleoperation Systems for Synchronization in Time (I), pp. 1736-1741.

Liu, Yanbin
Harbin Institute of Technology
Sun, Weichao
Harbin Institute of Technology
Chen, Zheng
Zhejiang University

12:00-12:15 ThAT6.5
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Islam, Shafiqul
Xavier University of Louisiana

ThAT7 Room T7

ThAT8 Room T8
Robotic Manipulators III (Regular Session)
Chair: Chen, Zheng
Zhejiang University
Co-Chair: Lei, Zike
University of Windsor

11:00-11:15 ThAT7.1

Murakami, Kenichi
University of Tokyo
Ishimoto, Koki
University of Tokyo
Senoo, Taku
Hiroshima University
Ishikawa, Masatoshi
University of Tokyo

11:15-11:30 ThAT7.2
An Efficient Inverse Kinematics Algorithm for Continuum Robot with a Translational Base, pp. 1754-1759.

Lu, Jiaria
School of Mechanical Engineering, Shandong University
Du, Fuxin
School of Mechanical Engineering, Shandong University
Zhang, Tao
School of Mechanical Engineering, Shandong University
Wang, Dechen
School of Mechanical Engineering, Shandong University
Lei, Yangjiang
School of Control Science and Engineering, Shandong University

11:30-11:45 ThAT7.3
RBF Neural Network Based Adaptive Robust Control for Nonlinear Bilateral Teleoperation Manipulators with Uncertainty and Time Delay, pp. 1760-1771.

Chen, Zheng
Zhejiang University
Huang, Fanghao
Zhejiang University
Sun, Weichao
Harbin Institute of Technology
Gu, Jason
Dalhousie University
Yao, Bin
Zhejiang University

11:45-12:00 ThAT7.4
HILS Using a Minimum Number of Joint Module Testbeds for Analyzing a Multi-DoF Manipulator, pp. 1772-1779.

Noda, Yusuke
Tokyo City University
Tsujita, Teppei
National Defense Academy of Japan
Abiko, Satoko
Shibaura Institute of Technology
Sato, Daisuke
Tokyo City University
Nenchev, Dragomir
Tokyo City University

12:00-12:15 ThAT7.5
Infinite Torsional Motion Generation of a Spherical Parallel Manipulator with Coaxial Input Axes, pp. 1780-1785.

Tursynbek, Iliyas
Nazarbayev University
Shintemirov, Almas
Nazarbayev University

ThAT8 Room T8
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Chair: Hashimoto, Hideki
Co-Chair: Xie, Yuanlong

11:00-11:15 ThAT8.1 Sliding-Mode Control with Multi-Sensor Fusion for Orientation of Spherical Motion Platform, pp. 1786-1791.
Lee, seong-min Ulsan National Institute of Science and Technology
Son, Hungsun Ulsan National Institute of Science and Technology

11:15-11:30 ThAT8.2 Coupled Sliding Mode Control of an Omnidirectional Mobile Robot with Variable Modes, pp. 1792-1797.
Xie, Yuanlong Huazhong University of Science and Technology
Zhang, Xiaolong Huazhong University of Science and Technology
Meng, Wei Wuhan University of Science and Technology
Xie, Shane University of Leeds
Jiang, Liquan Huazhong University of Science and Technology
Meng, Jie Huazhong University of Science and Technology
Wang, Shuting Huazhong University of Science and Technology

11:30-11:45 ThAT8.3 Study on Self-Position Estimation and Control of Active Caster Type Omnidirectional Cart with Automatic / Manual Driving Modes, pp. 1798-1803.
Miyashita, Kenji Tokyo University of Agriculture and Technology
Wada, Masayoshi Tokyo University of Agriculture and Technology

11:45-12:00 ThAT8.4 A Two-Wheeled Type Vehicle to Carry Luggage in Cooperation with Human, pp. 1804-1809.
Matsubara, Hironori Chuo University
Nagatsu, Yuki Chuo University
Hashimoto, Hideki Chuo University

12:00-12:15 ThAT8.5 Iterative Super-Twisting Sliding Mode Control: A Case Study on Tray Indexing, pp. 1810-1815.
Wang, Wenxin National University of Singapore
Ma, Jun National University of Singapore
Li, Xiaocong A*STAR
Zhu, Haiyue Singapore Institute of Manufacturing Technology
Teo, Chek Sing SIMTech
Lee, Tong Heng National University of Singapore

Human-Centered Robotics (Invited Session)

Chair: Guo, Jiajie
Co-Chair: Chen, Siyu

11:00-11:15 ThAT9.1 Non-Periodic Lower-Limb Motion Recognition with Noncontact Capacitive Sensing (I), pp. 1816-1821.
Zheng, Enhao Institute of Automation, Chinese Academy of Sciences
Zeng, Jincheng School of Automation and Electrical Engineering, University of S
Xu, Dongfang Peking University
Wang, Qining Peking University
Qiao, Hong Institute of Automation, Chinese Academy of Sciences

Guo, Jiajie Huazhong University of Science and Technology
fu, jianyong Huazhong University of Science and Technology
Lee, Kok-Meng Georgia Institute of Technology

Guo, Xingzhao Peking University
Zhou, Zhihao Peking University
Ma, Jingeng Peking University
Wang, Qining Peking University

11:45-12:00 ThAT9.4 Pilot Study of a Hover Backpack with Tunable Air Damper for Decoupling Load and Human (I), pp. 1834-1839.
Zhang, Bin Zhejiang University
Liu, Yong Guangdong Eco-Engineering Polytechnic
Fan, Wu Zhejiang University
Wang, Zenghao Zhejiang University
Liu, Tao Zhejiang University

12:00-12:15 ThAT9.5 A Novel Soft Robotic Glove with Positive-Negative Pneumatic Actuator for Hand Rehabilitation, pp. 1840-1847.
Hu, Debin Xi'an Jiaotong University
zhang, Jinhua Xi'an Jiaotong University
Yang, Yuan Xi'an Jiaotong University
Li, Qiuyang Xi'an Jiaotong University
Li, Dahai Xi'an Aerospace Propulsion Test Technology Institute
Hong, Jun Xi'an Jiaotong University
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**Chair:** Kamezaki, Mitsuhiro  
**Co-Chair:** Coleman, Demetris

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Konno, Minoru  
Onuki, Akhiko  
Sugano, Shigeki |
| 11:15-11:30 | **ThAT10.2** Extension of the Capture Range under High-Speed Motion Using Mirror Galvanometers, pp. 1854-1859. | Ezaki, Yuriko  
Moko, Yushi  
Ikeda, Haruka  
Hayakawa, Tomohiko  
Ishikawa, Masatoshi |
| 11:30-11:45 | **ThAT10.3** Bolt Loosening Detection Using Multi-Purpose Robot Hand, pp. 1860-1866. | Shimada, Fumiya  
Senoo, Taku  
Murakami, Kenichi  
Ishikawa, Masatoshi |
| 11:45-12:00 | **ThAT10.4** Magnetic Machine Perception for Reconstruction of Non-Uniform Electrical Conductivity Based on Eddy Current Model, pp. 1867-1877. | Hao, Bingjie  
Lee, Kok-Meng  
Chang, Ivy |
| 12:00-12:15 | **ThAT10.5** Comprehensive Performance Evaluation of Large Span Metal Roof Based on AHP-FCE (I), pp. 1878-1883. | Yang, Xueyao  
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### Rehabilitation Robots II (Regular Session)

**Chair:** Wang, Qining  
**Co-Chair:** Hunte, Kyle

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| 11:15-11:30 | **ThAT11.2** Online Estimation of Continuous Gait Phase for Robotic Transstibial Prostheses Based on Adaptive Oscillators, pp. 1890-1895. | Xu, Dongfang  
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| 11:30-11:45 | **ThAT11.3** Design and Compliance Control of Rehabilitation Exoskeleton for Elbow Joint Anchylosis, pp. 1896-1901. | zhang, sihan  
Zhu, Qiguqo  
Wu, Jun  
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Gu, Yong |
| 11:45-12:00 | **ThAT11.4** On the Design of Rigid-Soft Hybrid Exoskeleton Based on Remote Cable Actuator for Gait Rehabilitation (I), pp. 1902-1907. | Zhou, Zhihao  
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**Modeling and Analysis of Mechatronic Systems (Regular Session)**

**Chair:** Mihalec, Marko  
**Co-Chair:** Sakai, Satoru

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Isaka, Keita  
Tsumura, Kazuki  
Watanabe, Tomoki  
Okui, Manabu  
Yoshida, Hiroshi |
| 11:15-11:30 | **ThAT12.2** | |
Analysis and Validation of a New Hydraulic Cylinder Nominal Dynamics, pp. 1914-1921.

Sakai, Satoru Shinshu Univ

11:30-11:45 ThBT1.3


Wang, Yu-Hsun National Taiwan University
Lo, Yuan Chieh Industrial Technology Research Institute
Lin, Pei-Chun National Taiwan University

11:45-12:00 ThBT1.4


Schmerbauch, Anja E. M. University of Groningen
Vakis, Antonis I. University of Groningen
Huisman, Robert SRON Netherlands Institute for Space Research
Jayawardhana, Bayu University of Groningen

ThBT2 Room T2

Control of Mechatronic Systems II (Regular Session)

Chair: Solanki, Pratap Bhanu Michigan State University
Co-Chair: Li, Perry University of Minnesota

13:30-13:45 ThBT2.1

Design and Control of a MAGLEV Platform for Positioning in Arbitrary Orientations, pp. 1935-1942.

Wertjanz, Daniel Technische Universität Wien
Csencsics, Ernst Vienna University of Technology
Schlarp, Johannes Vienna University of Technology
Schitter, Georg Vienna University of Technology

13:45-14:00 ThBT2.2

An Efficient Control Transition Scheme between Stabilization and Tracking Task of a MAGLEV Platform Enabling Active Vibration Compensation, pp. 1943-1948.

Wertjanz, Daniel Technische Universität Wien
Csencsics, Ernst Vienna University of Technology
Schlarp, Johannes Vienna University of Technology
Schitter, Georg Vienna University of Technology

14:00-14:15 ThBT2.3


Solanki, Pratap Bhanu Michigan State University
Bopardikar, Shaunak D. Michigan State University
Tan, Xiaoob Michigan State University

14:15-14:30 ThBT2.4


Chatterjee, Arpan University of Minnesota, Twin Cities
Li, Perry University of Minnesota

14:30-14:45 ThBT2.5


LEE, YU-HSIU University of California, Los Angeles
Li, Xinzhou University of California, Los Angeles
Simonelli, James University of California, Los Angeles
Lu, David University of California, Los Angeles
Wu, Holden University of California, Los Angeles
TSAO, Tsu-Chin University of California Los Angeles

ThBT4 Room T4

SLAM and Navigation (Regular Session)

Chair: Ye, Cang Virginia Commonwealth University
Co-Chair: Xiong, Zhenhua Shanghai Jiao Tong University

13:30-13:45 ThBT4.1


WEI, Weichen Monash University
Shirinzadeh, Bijan Monash University
Ghafarian, Mohammadali Monash University
Esakkiaappan, Shunmugasundar Monash University
Shen, Tianyao Monash University

13:45-14:00 ThBT4.2


Gao, Xitian Tiangong University
Li, Baoquan Tiangong University

14:00-14:15 ThBT4.3


Zhu, Zhikai Institute of Automation, Chinese Academy of Sciences
Wang, Wei Institute of Automation, Chinese Academy of Sciences

14:15-14:30 ThBT4.4


LEE, CHANGYO Shanghai Jiaotong University
Peng, Jichao Shanghai Jiao Tong University, School of Mechanical Engineering
Xiong, Zhenhua Shanghai Jiao Tong University

14:30-14:45 ThBT4.5


Ye, Cang Virginia Commonwealth University
Zhang, He Shanghai Jiao Tong University
Jin, Lingqiu Virginia Commonwealth University
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<td><strong>14:15-14:30</strong></td>
<td><strong>14:30-14:45</strong></td>
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<td><strong>FPGA-Based Characterization and Q-Control of an Active AFM Cantilever</strong>, pp. 2062-2067.</td>
<td><strong>ThBT7.3</strong></td>
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<td>Kaveh, Orod</td>
<td>Forstenhüäsler, Marc</td>
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<td>Coskun, M. Bulut</td>
<td><strong>13:30-13:45</strong></td>
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<td>MAHDAVI, MOHAMMAD</td>
<td><strong>Optimized Mobile Robot Positioning for Better Utilization of the Workspace of an Attached Manipulator</strong>, pp. 2074-2079.</td>
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<td>Moheimani, S. O. Reza</td>
<td>Forstenhüäsler, Marc</td>
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<td><strong>ThBT7.1</strong></td>
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13:45-14:00  ThBT7.2
Fuzzy Kinematic Reliability of a Cartesian Parallel
Manipulator with Clearances, pp. 2080-2085.
Lara Molina, Fabian Andres  Federal University of Technology - Paraná
Dumur, Didier  Supelec

14:00-14:15  ThBT7.3
Electrophoresis-Based Adaptive Manipulation of Nanowires in
Fluid Suspension, pp. 2086-2096.
Wu, Juan  Binghamton University
Li, Xilin  Binghamton University
Yu, Kaiyan  Binghamton University

14:15-14:30  ThBT7.4
Image Guided Autonomous Grasping and Manipulation for
Valve Turning, pp. 2097-2102.
Islam, Shafiqul  Xavier University of Louisiana
Dias, Jorge  University of Coimbra

14:30-14:45  ThBT7.5
Metrics and Methods for Evaluating Learning Outcomes and
Learner Interactions in Robotics-Enabled STEM Education, pp.
2103-2108.
Rahman, S M Mizanoor  University of West Florida
Noncontact Steering of Magnetic Objects by Optimal Linear Feedback Control of Permanent Magnet Manipulators

Nayereh Riahi1, Arash Komae1
1Southern Illinois University, Carbondale

• Our manipulator consists of an array of six radially magnetized cylindrical magnets, equipped with individual servomotors.
• A linear state feedback determines the directions of magnets to steer a magnetic object along a reference trajectory.
• To develop an approximate linear model for design of this linear control, an optimization problem has been formulated and solved to obtain the best equilibrium point.

Bio-Magnetic/Eddy-Current Sensor Design for Biological Object Detection

Chun-Yeon Lin, Yi-Chin Wu, Yuan-Liang Chen, Shih-Cheng Huang
Department of Mechanical Engineering, National Taiwan University, Taiwan

• This paper presents a distributed current source (DCS) based method to develop a bio-magnetic/eddy-current (Bio-MEC) sensor for biological object detection.
• The electromotive force of the differential coil system is formulated in a closed-form solution by the DCS method for design analysis of the Bio-MEC sensor.
• With a prototype of Bio-MEC sensor, the implementation and measurement procedures of applying sweep frequency analysis on meat and bone have been illustrated experimentally.

Development of Magnetic Absolute Encoder Using Eccentric Structure: Improvement of Resolution by Multi-Polarization

Keita Sado1, Yusuke Deguchi1, Yuki Nagatsu1, and Hideki Hashimoto1
1Department of Electrical, Electronic, and Communication Engineering
Chuo University, Tokyo, Japan

• Point 1. The purpose is to improve the resolution of magnetic encoders by using only one multipole magnet.
• Point 2. The absolute angle can be calculated by using the features caused by eccentric rotation.
• Point 3. To accurately calculate the angle, Hall ICs are required for a number of poles of the magnet.

Data-Driven Multi-Objective Controller Optimization for a Magnetically-Levitated Nanopositioning System

Xiaocong Li1, Haiyue Zhu1, Jun Ma2, Tat Joo Teo1, Chek Sing Teo1, Masayoshi Tomizuka2, Tong Heng Lee3
1Singapore Institute of Manufacturing Technology, A*STAR
2Department of Mechanical Engineering, University of California, Berkeley
3Department of Electrical and Computer Engineering, National University of Singapore

• The proposed algorithm learns from the past non-optimal motion data to iteratively improve the motion control performance.
• A multi-objective cost function is suitably designed to consider both smooth and accurate trajectory tracking.
• Its potential can be further explored in other robotic systems, e.g., quadrotors, legged robots and soft robots etc.
Modeling and Control of Actuators

Chair Zheng Chen, Zhejiang University
Co-Chair Yanyang Liu, Harbin Institute of Technology

10:15–10:30
TuAT2.1

Hybrid Model Based on the Maxwell-Slip Model and a Support Vector Machine for Hysteresis in Piezoelectric Actuators
S. Xie\textsuperscript{1,2}, C. Ni\textsuperscript{1}, H. Duan\textsuperscript{1,3}, Y. Liu\textsuperscript{1}, N. Qi
\textsuperscript{1}Harbin Institute of Technology
\textsuperscript{2}Shanghai Academy of Spaceflight Technology
\textsuperscript{3}Beijing Institute of Space Mechanics & Electriciy

- A hybrid model based on both data-based and phenomenological models is proposed.
- The Maxwell-slip (MS) model is utilized to capture hysteresis.
- The least-squares support vector machines (LS-SVM) is used to capture the remaining modeling errors.

10:45–11:00
TuAT2.3

Underwater Buoyancy and Depth Control Using Reversible PEM Fuel Cells
Alicia Keow\textsuperscript{1}, Wenyu Zuo\textsuperscript{1}, Fathi Ghorbel\textsuperscript{2}, and Zheng Chen\textsuperscript{1}
\textsuperscript{1}Department of Mechanical Engineering, University of Houston, Houston, TX, 77204 USA.
\textsuperscript{2}Department of Mechanical Engineering, Rice University, Houston, TX, 77251 USA.

- Development of a compact energy efficient VBS prototype actuated by RFC.
- Design and tune depth controller with consideration for the nonlinear and time-varying RFC actuated VBS.
- Experimentally validate trajectory planner with PDA feedback controller to maneuver the VBS between two known depths.

11:00–11:15
TuAT2.4

Moment of Inertia Estimation and Friction Coefficient Identification for Servo Drive Systems
Ming-Tsung Lin\textsuperscript{1,2}, Han-Yu Lai\textsuperscript{1}, Kuang-Chih Liu\textsuperscript{1}, Jih-Chieh Lee\textsuperscript{3}
and Chien-Yi Lee\textsuperscript{1}
\textsuperscript{1}National Formosa University, Taiwan
\textsuperscript{2}Smart Machine and Intelligent Manufacturing Research Center, Taiwan
\textsuperscript{3}IMTD, Industrial Technology Research Institute, Taiwan

- An BMVFD method is proposed to identify mechanical parameters.
- Based on the identified model, controller gains of servo loops are optimized.
- A virtual machine tool is adopted to predict control performance.
- The effectiveness of the method is validated on a servo drive system.

11:15–11:30
TuAT2.5

Distributed Control Strategies for Modular Permanent Magnet Synchronous Machines Taking Into Account Mutual Inductances
Lynn Verkroost\textsuperscript{1,2}, Hendrik Vansompel\textsuperscript{1,2}, Frederik De Belie\textsuperscript{1,2}, Peter Sergeant\textsuperscript{1,2}
\textsuperscript{1}Ghent University, Belgium
\textsuperscript{2}Flanders Make@UGent – EEDT-MP

- To fully exploit the flexibility and reliability of modular motor drives, distributed control is required.
- Mutual coupling between the stator windings affects the control performance.
- The proposed distributed control strategy makes use of communication between neighboring windings to approach the control performance of centralized control.
### Bipedal Walking Based on Improved Spring Loaded Inverted Pendulum Model with Swing Leg (SLIP-SL)

Mustafa Melih Pelit¹, Junho Chang¹, Rin Takano¹ and Masaki Yamakita¹
¹School of Engineering, Department of Systems and Control Engineering, Tokyo Institute of Technology.

- SLIP model is a popular template to realize walking motion with bipedal robots but it doesn’t provide information about swing leg motion
- We extend SLIP model by adding passive swing leg dynamics
- Direct collocation method is used to find proper parameters for SLIP-SL and it is shown on simulation that it can be used to realize cyclic gait of a 5 linked biped robot

### Strict Stealth Walking of Planar Point-Footed Biped with Extra Control Torques

Fumihiko Asano¹, Ryosuke Kondo¹ and Hiroki Shibata¹
¹School of Information Science, Japan Advanced Institute of Science and Technology

- Stable walking motions of a point-footed biped are generated on a friction-less road surface based on the method of strict stealth walking.
- The stance- and swing-leg motions are strictly and preferentially controlled to follow the desired trajectories.
- The active reaction wheels on the leg frames are successfully controlled to satisfy the condition of angular momentum constraint control.

### Comparison of performance of human and bird walkers

Rodrigo Matos Carnier
Advisor: Prof. Yasutaka Fujimoto
Fujimoto Lab

June/2020
Mobile Robots I

Chair Feitian Zhang, George Mason University
Co-Chair Masayoshi Wada, Tokyo University of Agriculture and Technology

10:15–10:30 TuAT4.1

Novel angled spoke-based mobile robot design for agile locomotion with obstacle-overcoming capability
Youngjoo Lee¹, Dupyo Yoon¹, Joohyun Oh¹, Hwa Soo Kim², TaeWon Seo¹
¹Mechanical Engineering, Hanyang University, Seoul, Korea
²Mechanical Engineering, Hanyang University, Seoul, Korea

• Novel angled-spoke based mobile robot design is suggested.
• As the spoke trajectory does not reach the top of the body, additional mounting devices can be included.
• Max. speed is approximately 18 body lengths/s on the carpet, and the robot could carry the 100% of the robot weight.
• The robot could overcome 0.7 times of a spoke length height.

10:45–11:00 TuAT4.3

STEP: A New Mobile Platform with 2-DOF Transformable Wheels for Service Robots
Youngsoo Kim¹, Yunhyuk Lee², Seungmin Lee³, Jongwon Kim¹, Hwa Soo Kim², TaeWon Seo²
¹Mechanical Engineering, Seoul National University, Seoul, Korea
²Mechanical Engineering, Hanyang University, Seoul, Korea
³Mechanical System Engineering, Kyonggi University, Suwon Korea

• A 5-bar mechanism is combined with a 4-bar slider-crank mechanism to separate the wheel transformation from the wheel rotation.
• Kinematic analysis of wheel mechanism is performed.
• Experiments verify that the new mobile platform STEP can overcome various obstacles encountered in indoor environments.

11:00–11:15 TuAT4.4

ACROBAT-S Omnidirectional Mobile Robot Prototype And Study on Ball Drive Mechanism
Kosuke Kato, Masayoshi Wada
Tokyo University of Agriculture and Technology, Japan

• This paper presents a holonomic omnidirectional mobile robot using an active-caster robotic drive with a single ball transmission (ACROBAT-S).
• The mechanism includes a unique drive train with a ball-roller traction system to drive the omnidirectional wheel system.
• We confirmed the operation of the prototype and examined the influence of the drive roller arrangement on the drive force.

11:15–11:30 TuAT4.5

Background Flow Sensing for Autonomous Underwater Vehicles Using Model Reduction with Dynamic Mode Decomposition
Fengying Dang, Sanjida Nasreen
Feitian Zhang
Department of Electrical and Computer Engineering
George Mason University
Fairfax, VA
Model-based control of a novel planar tendon-driven joint having a soft rolling constraint on a plane

Ken Masuya\(^1\) and Kenji Tahara\(^2\)
\(^1\)School of Engineering, Tokyo Institute of Technology
\(^2\)Faculty of Engineering, Kyushu University

- A novel planar tendon-driven joint with a soft cylinder contacting a rigid plane
- Model-based point-to-point controller of the proposed joint
- Reference path generator of the radius variation based on a soft rolling constraint for accurate control of rolling distance

Optimal Design of a Motor-Driven Three-Finger Soft Robotic Gripper

Chih-Hsing Liu, Fu-Ming Chung, Yang Chen, Chen-Hua Chiu, and Ta-Lun Chen
Department of Mechanical Engineering, National Cheng Kung University, Taiwan

- The topology optimized compliant finger is superior to previous design in terms of reducing maximum finger stress and driving force while maintaining similar value of geometric advantage.
- The gripper can grip object with a maximum size of 140mm, and a maximum weight of 4.2kg. The load capacity can vary according to the friction between gripper and object. The maximum payload can be increased to 9.6kg when an additional anti-slip foam tape is applied on the grip surfaces of the fingers.
- An vision-based robotic grasping system is developed for autonomously adaptive grasping of size-varied delicate objects.

Characteristics of a Tendon Driven Soft Gate for Canal Flow Regulation

Mohamed Tahir Shoani\(^1\), Mohamed Najib Ribuan\(^1\), Ahmad Alhif
Mohd Faudzi\(^1\)
\(^1\)Faculty of Electrical & Electronic Eng. Universiti Tun Hussein Onn Malaysia, Parit Raja, 86400, Johor, Malaysia.
\(^2\)School of Electrical Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, Skudai, 81310, Johor, Malaysia

- Soft Gate for Irrigation Control.
- Controllable through tendon retraction.
- Lower cost, easier to install and relocate.
- One size of the manipulator arm can fit many canal widths.
Tactile and Force Sensing

Chair Peng Qi, Tongji University
Co-Chair Tong Zhang, University of Windsor

10:15–10:30  TuAT6.1
Enhancement of Performance on Sensor-less Force Sensation Using Singular Spectrum Analysis Based Force Observers

Thao Tran Phuong¹, Kiyoshi Ohishi¹, Yuki Yokokura¹
¹Nagasaki University of Technology, Japan

- High performance force-sensor-less observer approaches based on singular spectrum analysis (SSA) are presented.
- The SSA based force observers have the advantages of effective noise suppression, more accurate force estimation and wideband force sensing.
- The superior performance of SSA in signal decomposition and noise attenuation is very useful for a wide range of applications in motion control.

10:45–11:00  TuAT6.3
Collision Detection of Robots Based on a Force/Torque Sensor at the Bedplate

Wang Li¹, Yong Han¹, Jianhua Wu¹, and Zhenhua Xiong¹
¹State Key Laboratory of Mechanical System and Vibration, School of Mechanical Engineering, Shanghai Jiao Tong University

- This paper presents a novel collision detection scheme based on the robot’s dynamic model that calculates the reaction force/torque at the bedplate.
- To identify the dynamic model, a systematic procedure by measuring the force and torque at the robot’s bedplate with a force/torque sensor is introduced.
- Collision detection experiments are conducted on a test-bed and humans.

11:00–11:15  TuAT6.4
Criminisi Algorithm Applied to a GelSight Fingertip Sensor for Multi-modality Perception

Xinran Li¹, Wanlin Li², Yu Zheng³, Kaspar Althoefer², Peng Qi¹
¹Dept. of Control Science and Engineering, Tongji University, Shanghai, China.
²Centre for Advanced Robotics, Queen Mary University of London, UK.
³Tencent Robotics X, Tencent Binhai Building, Shenzhen, China.

- The fingertip sensor is to concurrently detect contact force and rebuild the object shape.
- A combination of a coated silicone elastomer and an internal spring structure are used to determine force information.
- The tactile-related information is generalized from the force-related information by using the Criminisi algorithm.

11:15–11:30  TuAT6.5
Simulation of Tactile Sensing Arrays for Physical Interaction Tasks

Z. Kappassov¹, Author_2², J. Corrales², and V. Perdereau²
¹Robotics Department, Nazarbayev University, Kazakhstan
²Institute Pascal, SIGMA Clermont, France

- A framework for tactile servoing in the simulated world
- A point spread function preserves the properties of the elastic layer on a real sensor
- An edge servoing controller was implemented using Robot Operating System (ROS) and Gazebo simulation environment with Open Dynamics Engine (ODE)
Control of Robotic Manipulators I

Chair Joerg Mareczek, University of Applied Sciences of Landshut
Co-Chair Min Cheol Lee, Pusan National University

10:15–10:30 TuAT7.1

Trajectory Tracking Control Using Fractional-Order Terminal Sliding Mode Control with Sliding Perturbation Observer for a 7-DOF Robot Manipulator

Wang Jie, Zhou Yudong, Bao Yulong, Hyun Hee Kim and Min Cheol Lee
Pusan National University

- A new controller, FOTSMCSPO with high precision in tracking and lesser chattering was designed for a 7-DOF robot.
- The sliding surface, FOTSMC provides a fast convergence speed.
- SPO can reduce the chattering efficiently and enhance robustness for this robot in practice.

10:45–11:00 TuAT7.3

Dynamics of Cable Driven Parallel Manipulator (CDPM) Allowing Cable Wrapping Over Rigid Link

Man Cheong Lei
Chow Yuk Ho Technology Centre for Innovative Medicine
The Chinese University of Hong Kong

- Cable-link interference in CDPM is modelled as a cable wrapping on rigid-link phenomenon
- Jacobian matrices mapping the cable space to the body space and joint space accounting for the wrapping phenomenon are developed
- Cable forces are solved through optimization approach and are found to be more accurate compared with the case without wrapping
- Fidelity in modelling enhances and the accessible workspace of a CDPM expands

10:30–10:45 TuAT7.2

Adaptive Neural Network Observer Based PID-Backstepping Terminal Sliding Mode Control for Robot Manipulators

Ruidong Xi1, Zhixin Yang1, Xiao Xiao2
1University of Macau
2National University of Singapore

- Point 1. A single weight adaptive RBFNN based state and disturbance observer is developed with higher online learning efficiency, which is much more conducive to practical engineering applications.
- Point 2. A novel observer based controller named PID-backstepping terminal sliding mode control is proposed.
- Point 3. Performance compare results with the related PID, Backstepping, terminal sliding mode control and backstepping terminal sliding mode approaches are provided to show the superiority of the proposed method.

11:00–11:15 TuAT7.4

Precision Motion Control of a 6-DoFs Industrial Robot with Accurate Payload Estimation

Jinfei Hu1, Chen Li1, Zheng Chen1, Bin Yao2
1State Key Laboratory of Fluid Power and Mechatronic Systems, Zhejiang University
2School of Mechanical Engineering, Purdue University

- Introduction
- Dynamic Parameters Identification
- Robot DIARC Design
- Payload Estimation Design
- Experimental Results
- Conclusion

11:15–11:30 TuAT7.5

Local Optimal Tracking Control for Manipulators with Restrictive Joint Velocity and Acceleration Limits

Joerg Mareczek1
1Joerg.Mareczek@ieee.org, Faculty of Electrical and Industrial Engineering, Landshut University of Applied Sciences, Germany

- Velocity based tracking control of manipulators under speed and acceleration limitations
- Novel control method PDLC replaces inverse Jacobian based resolved motion rate control
- Based on constrained LS-optimization; analytic solution possible for RT-application
- Task-oriented specification of a set of TCP-coordinates which may show tracking errors
- No heuristics, no switching

2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
Energy-Optimal Velocity Planning for Connected Electric Vehicles at Signalized Intersection with Queue Prediction

Haoxuan Dong, Weichao Zhuang, Guodong Yin, Senior, IEEE, Hao Chen, Yan Wang
School of Mechanical Engineering, Southeast University, Nanjing, China.

- A novel eco-driving strategy is proposed with consideration of the waiting queue, for pass through a signalized intersection efficiently and energy-saving.
- An improved queue prediction method is developed to predict the queue movement, which considering the vehicle and driver dynamics.

Two-Level Mechatronics-Based Control Design for Concurrent Improvement of Terrain Mobility and Energy Efficiency of an Open-Link Locomotion Module

Linhui Zhao1 and Vladimir V. Vantsevich2
1Harbin Institute of Technology, Harbin 150001, China
2University of Alabama at Birmingham, AL 35294, USA

- A design approach was developed to enhance performance of mechatronic systems while improving energy efficiency by establishing a synergizing balance between the performance and power losses in mechanical, electrical and control components of the system.
- An application of the approach to an off-road locomotion module with an electrical driveline allowed for a concurrent improving of the module’s terrain mobility and energy efficiency.

Digitization of Matrix-Headlights That Move as in the Real Test Drive

Mirko Waldner1, Maximilian Krämer1 and Torsten Bertram1
1Institute of Control Theory and Systems Engineering, TU Dortmund University, D-44221 Dortmund, Germany, mirko.waldner@tu-dortmund.de

- Hardware-in-the-Loop-Evaluations of real high-resolution matrix-headlight in a virtual world in real time
- Real Headlamp is moved by a mechanical actuator that simulates the vehicle dynamics
- The quality and usability of digitization under the influence of mechanical movement is evaluated with a real matrix headlight with 84 pixels
A compact and cost-effective pattern recognition based myoelectric control system for robotic prosthetic hands

Hao Zhou and Gursel Alici
ARC Centre of Excellence for Electromaterials Science & Applied Mechatronics and Biomedical Engineering Research (AMBER) Group, University of Wollongong, Australia

- Using only two sEMG-IMU sensors attached to a user's forearm, inline with a typical commercial myoelectric hand's sensor configuration
- Two additional sensors attached to the upper arm, not interfering with a user's existing forearm socket but providing more information of muscular activities
- Comparable recognition performance to those using 10 sensors on a user's forearm in the offline and online tests

Simultaneous and Proportional Estimation of Multi-Joint Kinematics from EMG Signals for Myocontrol of Robotic Hands

Qin Zhang, Te Pi, Runfeng Liu, Caihua Xiong
Huazhong University of Science and Technology

- Sparse pseudo-input Gaussian process (SPGP) is proposed to estimate multi-joint kinematics from EMG signals.
- The online kinematics estimation is accurate (CC=0.91) with contra-lateral training strategy.
- The kinematics estimation can be decoded in real time with negligible response delay (no more than 150 ms).
- The proposed estimation method has been verified in performing functional hand grasping tasks on eight subjects.

Redundant Haptic Interfaces for Enhanced Force Feedback Capability Despite Joint Torque Limits

Ali Torabi1, Kourosh Zareinia2, Garnette Sutherland3, Mahdi Tavakoli1
1 Electrical and Computer Eng., University of Alberta, Edmonton, Canada
2 Mechanical Eng., Ryerson University, Toronto, Canada
3 Faculty of Medicine, University of Calgary, Calgary, Canada

- An actuator saturation compensation method (ASCM) is proposed to enhances the force feedback capability of a redundant haptic interface.
- By employing ASCM, the required torque for rendering a stiff environment will be distributed among small-capacity actuators.
- The proposed method empowers design engineers to utilize smaller actuators that have lower rotor inertia and friction in the design of new haptic interfaces.
Distributed Optimization of Visual Sensor Networks for Coverage of a Large-scale 3-D Scene
Fan Jiang1, Xuebo Zhang2∗, Xiang Chen2, Yongchun Fang1
1 Institute of Robotics and Automatic Information System, Tianjin Key Laboratory of Intelligent Robotics, Nankai University, Tianjin 300380, China
2 Department of Electrical and Computer Engineering, University of Windsor, Ontario, Canada

- Merits:
  1. A new data structure called “chunk-triangle” is proposed to accelerate the visible triangle judgement especially for large-scale 3-D scenes. It is the first reported data structure which uses chunks in the 3-D Cartesian space to divide the object surface space into some subsets of triangles.
  2. We developed a fast, scalable and fully distributed approach consisting of space partition, distributed greedy search and local search strategy for the optimization of camera deployment for large-scale 3-D scenes.

Modeling Performance of a Stereo Camera Sensor for Optimization
Zike Lei1, Xi Chen1, Li Chai1
1 Wuhan University of Science and Technology, Hubei, 430081 China
2 University of Windsor, Ontario, N9B 3P4 Canada

- Detailed modeling of the stereo camera sensors.
- New criterion: new depth resolution and permissible degree of orientation (PDO).
- Optimize the performance of stereo camera sensor using gradient-ascent based algorithm and improved genetic algorithm.

Automated Dimensional Extraction Of Different Regions Using Single Monocular Camera In Pseudo-Stereo Configuration
Denzel Lee, Jingmin Liu, Shiawdy Michael Lee and Shaohui Foong
Engineering Product Development Pillar, Singapore University of Technology and Design, Singapore

- Deep learning based approach to automate the dimensional extraction process of specific targeted regions using stereo images.
- Stereo images obtained from a single monocular camera in a pseudo-stereo configuration that features custom linear actuator within BINO UAV.
- Achieved a measurement accuracy of an average 1.23mm RMSE and 2.23mm Max Error.

Visualy Compensating Eccentric In-plane Rotations for Image Stabilization on a Rotating Platform
Matthew Ng, Emmanuel Tang, Gim Song Soh, and Shaohui Foong
Engineering Product Development, Singapore University of Technology and Design, Singapore

- Eccentric rotation can contribute significant errors for pose estimation.
- Algorithm proposes estimation or errors using a trochoid model.
- Experiments shows algorithms ability to correct for errors up to sub-pixel accuracy.
Quasi-Direct Drive Actuation for a Lightweight Hip Exoskeleton with High Backdrivability and High Bandwidth

Shuangyue Yu1, Tzu-Hao Huang2, Xiaolong Yang1, Chunhai Jiao1, Jianfu Yang1, Yue Chen3, Jingang Yi3, Hao Su1
1Department of Mechanical Engineering, The City University of New York, City College, NY, 10023, US
2Department of Mechanical Engineering, University of Arkansas, Fayetteville, AR, 72701, US
3Department of Mechanical & Aerospace Engineering, Rutgers, The State University of New Jersey, Piscataway, NJ, 08854, US

Compact and Lightweight End-Effectors to Drive Hand-operated Surgical Instruments for Robot-Assisted Microsurgery

Namseon Jang1, Kyung-Tae Ihn1, N. Choi2, G. Gu2, J. Jeong3, S. Yang3, S. Yim1, K. Kim4, S. Oh1, and Donghyun Hwang1
1Korea Institute of Science and Technology, South Korea
2Korea University, South Korea
3Pohang University of Science and Technology, South Korea

ParaMaster: Design and Experimental Characterizations of a Haptic Device for Surgical Teleoperation

Xu Liu1, Baibo Wu1, Zhonghao Wu2, Lingyun Zeng1, and Kai Xu1
1School of Mechanical Engineering
2RII Lab (Lab of Robotics Innovation and Intervention), UM-SJTU Joint Institute
Shanghai Jiao Tong University, Shanghai, China
Compact Variable Gravity Compensation Mechanism 

with a Geometrically Optimized Lever 

for Maximizing Variable Ratio of Torque Generation

Jehyeok Kim1, Junyoung Moon2, Jongwon Kim1 and Giuk Lee2

1School of Mechanical Engineering, Seoul National University, South Korea
2School of Mechanical Engineering, Chung-Ang University, South Korea

- A compact variable gravity compensation mechanism using cam and variable pivot of lever is proposed.
- Lever shape is optimized to maximize the variable torque range.
- The verification test shows that optimized curved lever improves variable ratio by 270%.

Trajectory Planning Based on Minimum Input Energy for The Electro-hydraulic Cable shovel

Rujun Fan1, Yunhua Li1, Liman Yang1
1School of Automation Science and Electrical Engineering 
Beihang University, Beijing, China

- This paper deals with the work trajectory planning of a novel electric-hydraulic compound cable shovel using cubic polynomials.
- Three types of material piles with different pile angles (35°, 40°, and 45°) are compared with respect to the digging performance. Results show that the larger the pile angle is, the smaller the total energy consumption will be.

CAD Based Trajectory Optimization of PTP Motions using Chebyshev Polynomials

Nick Van Oosterwyck1, Abdelmajid Ben yahya1, Annie Cuyt2 Stijn Derammelaere

1Department of Electromechanics, CoSys-Lab, University of Antwerp
2Department of Mathematics and Computer Science, University of Antwerp

- This paper studies the use of Chebyshev polynomials for trajectory optimization of single degree of freedom (1-DOF) systems.
- Compared to results obtained using state-of-the-art techniques, an extra energy savings potential of 6.7% is established.
- For similar savings, the solve time has also been significantly reduced (-94.8%).

Design Optimization of Miniature Magnetorheological Valves with Self-Sensing Capabilities Used for a Wearable Medical Application

Sofia Lydia Ntella1, Minh-Trung Duong1, Yoan Civet1, Zoltan Pataky2 and Yves Parriard1

1Integrated Actuators Laboratory (LAI), École Polytechnique Fédérale de Lausanne (EPFL), Neuchâtel, Switzerland
2Division of Endocrinology, Diabetology, Nutrition and Therapeutic Education, Hôpitaux Universitaires de Genève

- Magneto-rheological (MR) pressure limiters for pressure offloading in wearable insole for diabetics
- MR valves optimization with regards to volume, power consumption and pressure drop
- Testbench for self-sensing possibilities of miniaturized MR valves
A New Sheath for Highly Curved Steerable Needles
University of North Carolina at Chapel Hill, NC 27599, USA
University of Utah, Salt Lake City, UT 84112, USA
Vanderbilt, Nashville, TN 37203, USA

Aiming Device for Steerable Needles
University of North Carolina at Chapel Hill, NC 27599, USA
University of Utah, Salt Lake City, UT 84112, USA
Vanderbilt, Nashville, TN 37203, USA

Geometry Optimization of a Noncontact Magnetic Manipulator with Rotatable Permanent Magnets
Nayereh Riahi, Southern Illinois University
Arash Komaeae, Southern Illinois University, Carbondale

Design and Compliance Control of Rehabilitation Exoskeleton for Elbow Joint Anchylloses
Sihan Zhang, Qiuguo Zhu, Jun Wu, Rong Xiong, Yong Gu
University of North Carolina at Chapel Hill, NC 27599, USA
University of Utah, Salt Lake City, UT 84112, USA

Guaranteed-cost H∞ Observer Gain for Under-Tendon-Driven Prosthetic Fingers
Diego Cardona, Guillermo Maldonado, Julio Fajardo
Turing Research Lab, Galileo University

Haptic Feedback Controlled Robot for Maneuvering in Large Spaces Engulfed by Fire
Chitransh Vishway, Tsegai Hidru, Shawnt Sarkissian, Kavithan Singarajah, Kourosh Zareinia
Department of Mechanical and Industrial Engineering, Ryerson University, Toronto, ON, Canada

2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
HAPTEL: Gesture Controlled Teleoperation System Complete with a Wearable Pneumatically Controlled Haptic Device
Alaa Moumneh¹, Ali Asad¹, Umer Jamil¹, Syed Asaad¹, Kourosh Zareinia¹
¹Department of Mechanical and Industrial Engineering, Ryerson University, Toronto, Ontario, Canada

- This study outlines the foundation technology for a larger system to mitigate risks for workers in hazardous areas.
- Simplicity and intuitiveness are at the forefront of this teleoperation system’s design.
- Pneumatically generating haptic feedback responses is an unorthodox method that has produced viable results.

Digital Twin Technology to Update Parameters of the Remaining Useful Life of a Ball Bearing
Sudev Nair ¹, Iniyan Ramasamy ², and Punyakoti N.S ³
¹Siemens Technology and Services Private Limited, Bengaluru, Karnataka, India
²Indian Institute of Technology - Madras, Chennai, Tamilnadu, India
³PES University, Bengaluru, Karnataka, India
¹sudev.nair@siemens.com, ²iniyanramasamy97@gmail.com, ³kotibrp22@gmail.com

Introduction
Ball bearings are crucial components in most of the rotating machineries. Main functions of a ball bearing include reducing friction between rotating surfaces and to support radial and axial load from the machinery. There are several reasons why bearings can be damaged or fail including,

- Inadequate or excess lubrication
- Misalignment
- Improper mounting
- Fatigue

Fig: Spalling due to fatigue load

Current Life Models
Optimising Parameters with Simulation Data

Material properties of the AISI 51200 steel

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elastic modulus</td>
<td></td>
<td>MPa</td>
</tr>
<tr>
<td>Poisson’s ratio</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Melting point</td>
<td>1424</td>
<td>°C</td>
</tr>
<tr>
<td>Shear modulus</td>
<td>80</td>
<td>GPa</td>
</tr>
<tr>
<td>Fatigue limit</td>
<td>900</td>
<td>MPa</td>
</tr>
</tbody>
</table>

Fig: Simulation of the bearing with outer race defect
Fig: Stress plot for elements marked in the simulation
The material used for the ball bearing was AISI 51200 steel. The bearing modelled was a 6319 with standard industry dimensions. It was simulated with a defect in the outer race of the bearing.

Fig: Comparison of various equation parameters in above mentioned life theory

Results
Given below is a table with the parameters obtained,

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Weibull</th>
<th>Lundberg - Palmgren</th>
<th>Ioannides - Harris</th>
<th>Proposed Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical shear stress, GPa</td>
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<td>Weibull slope e</td>
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<tr>
<td>Lundberg Palmgren parameters</td>
<td>9</td>
<td>9.3</td>
<td>9.3</td>
<td>9.3</td>
</tr>
<tr>
<td>Stress life exponent</td>
<td>10.8</td>
<td>9.0</td>
<td>19.6</td>
<td>16.8</td>
</tr>
</tbody>
</table>

Future Prospects
The mathematical model derived based on the proposed parameter optimization method has been implemented on Edge device locally to get instantaneous life parameters to help plant operating. This system when coupled with dynamic bearing data has the ability to tune in the parameters to accurately predict the bearing RUL.

Comparison of life theory equation parameters

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</tr>
</tbody>
</table>
**Design and Development of a High-force Haptic Device for Interaction with a Virtual Environment**

Asim Arif1, Taral Patel1, Taimour Shoail2 and Kourosh Zareinia1
1Department of Mechanical and Industrial Engineering
Ryerson University, Toronto, Ontario, Canada

- Design and development of a 3 degree-of-freedom haptic device that takes user input and simulates the movement in a virtual environment.
- Movement of end-effector translates to rotation of motor shafts which is detected by encoders.
- Encoder values transform into 3D coordinates using forward kinematics and fed into the virtualization, mimicking reality.

**Towards a Biomimetic and Dexterous Robot Avatar: Design, Control, and Kinematics Considerations**

Ahmad Sharifi-Nejad1, Etemad Mohseni1, Iraqi Zadeh1, Farrokh Janabi-Sharif1, Kourosh Zareinia1
1Ryerson University, Toronto, Ontario, Canada

- Bio-inspired design, taken originally from Youbionic, lightweight ABS exoskeleton instrumented with Linear Actuators for control
- Designed PID controllers for low level position control of each linear actuator
- Developed Kinematic Equations to convert between joint angles and cartesian representation in the workspace

**Online Torque Optimization of Wheeled Robots based on a Multi Objective Algorithm**

Diego Rosa, Marco Antonio Meggiolaro, Luiz Fernando Martha
Pontifical Catholic University of Rio de Janeiro, Brazil

- Use of genetic algorithms to improve torque distribution in applications in highly sloped terrains and step climbing.
- Development of a polynomial approach and generalization for real-time application.
- Experimental evaluation with two mobile robots in different challenging scenarios.
Radial Coverage Strength for Optimization of Multi-Camera Deployment

Zike Lei¹, Xi Chen¹*, Xiang Chen², Li Chai¹
¹ Wuhan University of Science and Technology, Hubei, 430081 China
² University of Windsor, Ontario, N9B 3P4 Canada

• A new criterion of coverage performance called Radial Coverage Strength.
• A fused coverage strength algorithm for calculating coverage performance.
• Using improved genetic algorithm to optimize overall coverage performance.

A camera sensor network coverage task
Towards Printing Mechatronics: 3D-printed conductive interfacing for digital signals

Andrei-Alexandru Popa¹, Jerome Jouffroy², Lars Duggen¹
¹University of Southern Denmark, SDU Mechatronics
²UCL University College

• 3D printing design considerations for microcontroller interfacing
• Stability and data transfer characteristics
• Case study and analysis
• Concluding remarks

Printing and Programming of In-Situ Actuators

Arash Alex Mazhari¹,², Alan Zhang², Randall Ticknor², Sean Swei², Elizabeth Hyde², Mircea Teodorescu¹
¹University of California, Santa Cruz, CA
²NASA Ames Research Center, Moffett Field, CA

• A novel method is presented to embed actuators onto the 3D printing platform and program their deflection.
• No additional hardware is required to attain actuator functionality. Actuation uses print head.
• Design space for desktop Fused Filament Fabrication 3D printer utilized to simulate and physically test 27 generations of actuators.

Layer-to-layer Predictive Control of Ink-jet 3D Printing

Uduak Inyang-Udoh¹, Yijie Guo², Joost Peters³, Tom Oomen⁴, Sandipan Mishra¹
¹Rensselaer Polytechnic Institute, NY, USA
²UBTECH Robotics, Beijing, China
³TNO, The Netherlands
⁴Eindhoven University of Technology, Eindhoven, The Netherlands

• Geometry-level model for control of inkjet 3D printing
• Scalable closed-loop distributed Model Predictive Control Algorithm for real-time geometry-level control
• Experimental validation of the Control Algorithm showing 33% improvement
Modeling and Control of Robots

Chair Yantao Shen, University of Nevada, Reno
Co-Chair Koichi Koganezawa, Tokai University

13:30–13:45 TuBT2.1

Wire-Tension Feedback Control for Continuum Manipulator to Improve Load Manipulability Feature

Azamat Yeshmukhametov1, Koichi Koganezawa, Yoshio Yamamoto
Tokai University
Askar Seidakhmet
Satbayev University

- Active and Passive wire-tension control
- Improves load manipulability
- Shape control
- Compact design

13:45–14:00 TuBT2.2

Modeling and Control of a Hybrid Wheeled Legged Robot: Disturbance Analysis

Fahad Raza1, Dai Owaki1, and Mitsuhiro Hayashibe2
1Graduate School of Engineering, Tohoku University.
2Graduate School of Biomedical Engineering and Graduate School of Engineering, Tohoku University.

- Motion stability analyses of the wheel-legged robot under different conditions such as system modeling errors, sensor noise, and external disturbances are performed.
- Linear quadratic regulator (LQR) control approach is adopted for balancing, steering, and translational position control of the robot.

14:00–14:15 TuBT2.3

Guidance and Control Law Design for a Slung Payload in Autonomous Landing

A Drone Delivery Case Study

Longhao Qian1, Silas Graham1, Hugh H.-T. Liu2
1, 2Institute for Aerospace Studies, University of Toronto, 4925 Dufferin Street, Toronto, Canada

- A proportional navigation based guidance law is designed to allow for soft landing (zero velocity when touching down).
- The guidance law can be easily integrated into a generic set-point drone control law to ensure smooth payload touchdown.
- The control development is verified by simulations and flight experiments.

14:15–14:30 TuBT2.4

Spline-Based Modeling and Control of Soft Robots

Shuzhen Luo1, Merrill Edmonds1, Jingang Yi2, Xianlian Zhou2, Yantao Shen3
1Dept. of Mech. and Aero. Eng., Rutgers University, Piscataway, NJ 08854, USA
2Dept. Of Biomed. Eng., New Jersey Institute of Technology, Newark, NJ 07102, USA

- Proposed dynamic non-uniform rational B-Spline (NURBS) model for soft robots to capture the exact geometric deformation with physical interactions
- Presented a real-time generalized predictive control for the NURBS model
- Simulated and demonstrated the efficiency of the modeling and control frame work using a snake-inspired autonomous soft robot

14:30–14:45 TuBT2.5

Depth-based Visual Predictive Control of Tendon-Driven Continuum Robots

Mostafa M.H. Fallah, Somayeh Norouzi-Ghashbi, Ali Mehrkish, Farrokh Janabi-Sharifi
Robotics, Mechatronics, and Automation Lab (RMAL) Department of Mechanical and Industrial Engineering, Ryerson University

- Formulation of a depth-based visual predictive control (DVPC) for continuum robots
- Performance evaluation using simulations
- Study of robustness to actuation and sensing uncertainties

2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
**Legged Robots II**

Chair Pranav Bhounsule, University of Illinois at Chicago
Co-Chair Tarik Yigit, Rutgers University

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**13:30–13:45 TuBT3.1**

**Analysis and Control of a Body-Attached Spring-Mass Runner Based on Central Pivot Point Approach**

O. Kaan Karagoz¹, Izel Sever¹, Uluc Savranli², M. Mert Ankarali²
¹Dept. of Computer Eng., Middle East Technical University
²Dept. of Electrical and Electronics Eng.

- Trunk-SLIP Model
- Central Pivot Point Concept
- Model Analysis
- Gait Controller
- Results

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**13:45–14:00 TuBT3.2**

**Exploiting the SoC FPGA Capabilities in the Control Architecture of a Quadruped Robot**

Chrysostomos Karakasis¹, Konstantinos Machairas³, Charalampos Marantos², Iosif S. Paraskevas¹, Evangelos Papadopoulos³, Dimitrios Soubris³
¹Department of Mechanical Engineering, University of Delaware, USA
²School of Electrical and Computer Engineering, NTUA, Greece
³School of Mechanical Engineering, NTUA, Greece

- Highly affordable centralized control architecture for a quadruped robot based on a SoC FPGA.
- Analysis of the architecture and evaluation compared with state-of-the-art approaches and earlier versions.
- Validation through trotting experiment with the quadruped robot Laelaps II.

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**14:00–14:15 TuBT3.3**

**Thruster-assisted Center Manifold Shaping in Bipedal Legged Locomotion**

Arthur C. B. Oliveira¹ and Alireza Ramezani¹
¹SiliconSynapse Lab, Northeastern University

- Thruster-assisted bipedal locomotion.
- Using thruster action to shape zero dynamics manifold and limit cycle of a bipedal walking gait.
- Simulation work to explore the effect of thruster action to contact forces.

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**14:15–14:30 TuBT3.4**

**A differential drive rimless wheel that can move straight and turn**

Sebastian Sanchez¹, Pranav A. Bhounsule¹
¹The University of Texas at San Antonio
²University of Illinois at Chicago

- Design: Two wheels individually powered, central body with electronics/computers
- Control
  - Straight: Motor current commanded to servo a constant body pitch angle
  - Turn: differential current added/subtracted to individual motor currents
- Results
  - 9.67 mph (top speed), 0.5 m turn radius
  - Total Cost of transport 0.13 (energy-efficiency)

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Localisation

Chair Yuanlong Xie, Huazhong University of Science and Technology
Co-Chair Maria Castano, Michigan State University

13:30–13:45 TuBT4.1

An Arc-Shaped Rotating Magnet Solution for 3D Localisation of a Drug Delivery Capsule Robot

Jaime Valls Miro, Fredy Munoz, Freyja Iriove Miguel
University of Technology Sydney (UTS), Australia

• 3D localisation of a drug delivery robot.
• Based on rotating fields generated by array of Arc-Shaped permanent magnets (ASM).
• Compatible with magnetic actuation for DDS.
• Highly non-uniform rotating fields lead to simple solution with a look-up table.
• Simulation and test-rig experimental results.
• Proof it is sufficient to rotate ASMs around 1 axis to obtain error < 10mm when scaled up.

14:00–14:15 TuBT4.3

Accurate LiDAR-based Localization in Glass-walled Environment

Jie Meng, Shuling Wang, Gen Li, Liquan Jiang, Yuanlong Xie and Chao Liu
School of Mechanical Science and Engineering, Huazhong University of Science and Technology, Wuhan, China.

• (1) a novel grid map with accurate glass information (GMGI) is constructed.
• (2) an improved ray-casting method is proposed.
• (3) scan matching with valid point cloud set is introduced into IRC-MCL, and it guarantees satisfactory localization accuracy in glass-walled environments.

13:45–14:00 TuBT4.2

Recursive Bayesian Estimation based Indoor Fire Location by Fusing Rotary UV Sensors

Jong-Hwan Kim1, Sangwoo Moon2
1Korea Military Academy, Seoul, South Korea
2Seoul National University, Seoul, South Korea

• A probabilistic fire location estimation in indoor fire environments was conducted by fusing two ultraviolet (UV) sensors
• In order to increase accuracy of the fire location under the uncertainty of fire environments, Recursive Bayesian estimation was applied to estimate fire location with belief between 0 and 1.
• For its validation, nine fire tests were implemented to create actual fire environments with varying fire locations.

14:15–14:30 TuBT4.4

Receiver Self-Localization for an Opto-Acoustic and Inertial Indoor Localization System

D. Esslinger, M. Oberdorfer, L. Kleckner, O. Sawodny, and C. Tarín
Institute for System Dynamics, University of Stuttgart, Stuttgart, Germany

• Indoor localization systems based on ultrasound and infrared can be used for quality assurance in manual assembly processes
• Unilateral distances measurements and inertial measurement data is used to find pose of transmitter
• Knowledge of room-fixed receivers through two different approaches:
  – Static self-localization with knowledge about relative position of transmitting piezoceramics
  – Dynamic self-localization which uses an Unscented Kalman Filter as an observer
• Experiments show absolute receiver positioning error below 3.2 cm (static) and 1.4 cm (dynamic)

14:30–14:45 TuBT4.5

A Geometry-Aware Hidden Markov Model for Indoor Positioning

Branislav Rudii1, Markus Pichler-Scheder1, Richard Schmidt1, Christian Helmiel1, Dmitry Efrosinin2, Christian Kastl1, Wolfgang Auer3
1Linz Center of Mechatronics GmbH
2Johannes Kepler University
3AISEMO GmbH

• Natural constraints in indoor positioning cannot be considered with Kalman or other Gaussian filters.
• We demonstrate how to adapt state space and transition matrix of a Hidden Markov Model to a given planar geometry.
• The proposed algorithm for decoding the maximum a posteriori (MAP) trajectory of the geometry-aware model shows an improved position accuracy.
Compliant Structures and Mechanisms
Chair Guoming George Zhu, Michigan State University
Co-Chair TIANYI HE, Michigan State University

### TuBT5.1
**Topology and Geometry Optimization for Design of a 3D Printed Compliant Constant-Force Mechanism**
Chih-Hsing Liu, Mao-Cheng Hsu, and Ta-Lun Chen
Department of Mechanical Engineering, National Cheng Kung University, Taiwan

- A topology and geometry optimization method to design a compliant constant-force mechanism that can provide a nearly constant output force over a range of input displacements.
- The optimized design is prototyped by 3D printing using flexible thermoplastic elastomer. Experimental results show the design can generate a nearly constant output force at output ports within the desired input displacement range.
- A soft and passive force regulation device which can be used in overload protection and output force control.

### TuBT5.2
**Closed-form solutions and analysis of the eigenmodes of Euler-Bernoulli beams with inner pinned support and end mass**
Simon Densborn, Oliver Sawodny
Institute for System Dynamics (ISYS), University of Stuttgart

- Eigenmodes and characteristic expressions of Euler-Bernoulli beams
- Inner pinned support at an arbitrary position
- Clamped, pinned, slide, free or mass boundary conditions
- Computational efficient closed form solution

### TuBT5.3
**Tool-center-point control of a flexible link concrete pump with task space constraints using quadratic programming**
Julian Wanner¹, Oliver Sawodny¹
1Institute for System Dynamics, University of Stuttgart

- Tool-center-point control of a concrete pump based on constrained quadratic programming
- Compensation of link flexibility
- Task space constraints for obstacle avoidance in a unified proximity query framework

### TuBT5.4
**Shape Memory Effect of Benchmark Compliant Mechanisms Designed with Topology Optimization**
A. Thabuis, S. Thomas, T. Martinez and Y. Perriard
Swiss Federal Institute of Technology Lausanne (EPFL)

- SMAs and Topology Optimization combined in a novel strategy with abstraction of the non-linear behavior
- Shape memory effect validated with commercial FEA software
- The work validates the possibility of designing complex SMA actuators using this method

### TuBT5.5
**Optimal Sensor Placement for Flexible Wings Using the Greedy Algorithm**
Tianyi He¹, Guoming Zhu¹, Sean Swei², Weihua Su³
¹Michigan State University
²NASA Ames Research Center
³University of Alabama

- Hybrid optimization formulation of the Optimal Sensor Placement (OSP) for a flexible wing in the LPV framework
- Using the greedy algorithm to solve the formulated optimization problem
- Comparison with conventional method in open-loop gridded LTI models

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2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
Grasping
Chair Tomoyuki Shimono, Yokohama National University
Co-Chair Tong Zhang, University of Windsor

13:30–13:45 TuBT6.1

A 3D Printed Modular Soft Gripper for Conformal Grasping
Charbel Tawk1,2, Rahim Mutlu1,2 and Gurses Ali1,2
1School of Mechanical, Materials, Mechatronic and Biomedical Engineering, University of Wollongong, Australia
2ARC Centre of Excellence for Electromaterials Science

• 3D printed Zig-Zag monolithic fingers that incorporate bioinspired fin-ray and compliant auxetic structures that highly reduce contact forces
• Gripper configuration can be easily and quickly modulated by changing the number of fingers attached to its base
• Gripper can grasp a wide variety of objects with different weights, shapes, sizes, textures and stiffnesses

14:00–14:15 TuBT6.3

Automatic Grasping Position Adjustment for Robotic Hand by Estimating Center of Gravity Using Disturbance Observer
Shotaro Yajima1,2, Tomoyuki Shimono3, Takahiro Mizoguchi1,2, Kouhei Ohnishi1,2
1The Graduate school of Engineering Science, Yokohama National University
2The Kanagawa Institute of Industrial Science and Technology
3The Faculty of Engineering, Yokohama National University

• Grasping position is adjusted automatically.
• The system is designed in the work space.
• The loads balance is estimated by disturbance observer using only rotary encoders

14:30–14:45 TuBT6.5

Suction Cup Based on Particle Jamming and Its Performance Comparison in Various Fruit Handling Tasks
Kieran Gilday, James Lilley and Fumiya Iida
Bio-Inspired Robotics Lab, University of Cambridge

• Fruit handling requires robust and secure suction with large irregularities between samples.
• Novel suction cup using particle jamming for malleability on highly irregular surfaces.
• Our design shows improvements in reliability for gripping a variety of surfaces.

13:45–14:00 TuBT6.2

Rigid Grasp Candidate Generation for Assembly Tasks
Suhan Park1, Jiyeong Baek1, Seungyeon Kim1, Jaeheung Park1
1Seoul National University, South Korea
2Advanced Institutes of Convergence Technology (AICT), South Korea

• Generation of grasp pose candidates for tasks requiring a great amount of force and high precision.
• It takes advantage of the antipodal-based methods and approach-based methods to increase the contact area and considers the grippers with the palm.
• A stricter limit is placed on the candidates than previous work but the candidates are still diverse.

14:15–14:30 TuBT6.4

Q-PointNet: Intelligent Stacked-Objects Grasping Using a RGBD Sensor and a Dexterous Hand
Chi-Heng Wang1, Pei-Chun Lin1
1Department of Mechanical Engineering, National Taiwan University, Taiwan

• Develop a pipeline to collect a partial point cloud and create Q-PointNet for producing the best grasp pose and its corresponding mode in a stacked circumstance. In addition, invent the GUI to prepare a dataset for our structure.
• Propose an algorithm to calculate finger width through the pose from Q-PointNet and verify the feasibility of this algorithm.
• Solve the problem of grasping specific objects from complex environments.
Encrypted Feedback Linearization and Motion Control for Manipulator with Somewhat Homomorphic Encryption

Kaoru Teranishi¹, Kiminao Kogiso¹, Jun Ueda²
¹The University of Electro-Communications
²Georgia Institute of Technology

We propose a method for encryption of nonlinear time-varying controllers.
• Encrypted controllers can be used for preventing eavesdropping attacks because control inputs are determined using encrypted sensor data.
• We demonstrated that feedback linearization and PD control of each joint of an RP manipulator can be encrypted by the proposed method.

Flow-Bounded Trajectory-Scaling Algorithm for Hydraulic Robotic Manipulators

Santeri Lampinen and Jouni Mattila
Tampere University, Finland

Santeri Lampinen and Jouni Mattila
Tampere University, Finland
Jouni Niemi
Rambooms Oy, Finland

This study proposes an on-line method for trajectory scaling to perform predetermined trajectories in minimum time without violating the volumetric flow rate constraint. Essentially, the method scales velocity along the trajectory to maintain achievable velocity at all times.
• The method is validated with simulations and experiments with a real hydraulic robotic manipulator.

Flow-limited path-following control of double Ackermann steered hydraulic mobile manipulator

L. Hulttinen and J. Mattila
Department of Automation Technology and Mechanical Engineering
Tampere University, Finland

• Flow-bounded path-following control of a wheeled hydraulic mobile manipulator
• Trajectory time scaling is achieved via:
  1) analytical platform velocity bounds (a priori-known hydraulic flow bounds), and
  2) arm tracking error based adaptation, to slow advancement in face of unexpected disturbances
• Simulation results verify the effectiveness of the approach

6 DOF anthropomorphic robot as a platform for teaching robotics

Juan Galarza¹, Luis Escobar¹, David Loza¹
¹Universidad de las Fuerzas Armadas - ESPE

• Many efforts have been made in the mechatronics field to develop robotic platforms based on open source platforms.
• The present work covers the design and implementation of a 6-degree-of-freedom anthropomorphic Open hardware and Open Software robot focused on education.
• The proposal to replicate the manipulator at undergraduate level proved to improve the technical performance of the participants, facilitating learning and assimilation of concepts that are complex to master theoretically.
Model-Based Knock Prediction and its Stochastic Feedforward Compensation
Ruixue C. Li and Guoming G. Zhu
Mechanical Engineering, Michigan State University, East Lansing, MI

- A model-based stochastic feedforward knock control strategy is proposed and demonstrated to regulate the cycle-by-cycle knock;
- The knock predictive model is based on a 0-D two-zone reaction-based combustion model and 1-D pressure wave model; and
- The control performance is demonstrated through simulations with a CIL reduction of 77.8%.

Effective Clamping Force Control for Electromechanical Brake System
Yijun Li1, Taehyun Shim1, Dong-Hwan Shin2, Seonghun Lee2, and Sungho Jin2
1University of Michigan-Dearborn
2Daegu Gyeongbuk Institute of Science & Technology

- Present an electromechanical brake system with the mechanical and clamping forces models.
- Introduce a clamping force estimator and a gap distance estimation algorithm.
- Develop a clamping force tracking controller using a disturbance observer with a PI feedback controller and a zero phase error tracking feedforward controller.

Shared Control Between Human Driver And Machine Based On Game Theoretical Model Predictive Control Framework
Sangjin Ko1, Reza Langari1
1Texas A&M University

- Motivation: There are two controllers in vehicle control loop and shared control strategy needs to be studied.
- Solution of game: Nash equilibrium is obtained as the best action w.r.t. the other’s best action.
- Simulation: Simulation under different target references of two players.
- Shared strategy: Collision probability and tracking error to define shared gain.

Turbocharger Waste Gate Sensitivity Based Adaptive Control
Vladimir V. Kokotovic (vvkokotov@ford.com); Xiaogang Zhang; Ford Research Innovation Center

1. Powerful electronics in the automotive industry has enabled applications of Artificial Intelligence, Machine Learning, Model Predictive Control, Neural Network and many other complex methodologies.
2. The complexity of these control systems has rapidly generated demand for improvements tools on system and subsystem control level.
3. Adaptive or self-optimizing control systems is one such tool which offers not only a significant reduction in calibration effort, but also offers better and long-lasting tracking, disturbance rejection and improved robustness in Intelligent Mechatronics.

Latest progress within AIM with the use of Sensitivity Based Adaptive Control will be presented in this paper.
J. Li, J. Yan, X. Liu, and G. Ouyang, "Using Permutation Entropy to Measure the Changes in EEG Signals During Absence Seizure to mental PE

Chen attention relaxation, emotional in meditation frequency was could The analysis self offline distribute psychological the Hz as admittance years, control with features average of improving non and and a results the proposed with PID W. L. Zheng, and B. L. Lu, "A multimodal approach to estimating vigilance using eeg and forehead eog", Journal of Neural Engi

Figure curves the reflect practice shown 1 applied EEG - Mechanical in 62 good charts non and in accuracies effective entropy research states, in a experiment, the conducted In B. R. Cahn, and J. Polich, "Meditation states and traits: EEG, ERP, and neuroimaging studies," Psychological Bulletin, vol. 1

We they clear state regions show offline PE has in entropy existing of states, in a experiment, the conducted In B. R. Cahn, and J. Polich, "Meditation states and traits: EEG, ERP, and neuroimaging studies," Psychological Bulletin, vol. 1

Accuracy

We show that the proposed admittance-based force control was effective in the human-robot interaction. In this study, PE is proposed to classify three mental states, 'attention', 'meditation', and 'relaxation' states, respectively.

Multiplicative valve to control many cylinders

Kevin M. Ferguson, Dayong Tong and Ryder C. Winck Rose-Hulman Institute of Technology

• A multiplicative valve array can control many hydraulic actuators using m + n valves (e.g. 100 actuators controlled by 20 valves)
• Using SVD or SNMF, all of the actuators can be simultaneously controlled
• Experimental results validate the multiplicative valve’s design

Admittance-Based Bio-Inspired Cognitive PID Control to Optimize Human-Robot Interaction in Power-Assisted Object Manipulation

S. M. M. Rahman
University of West Florida

The PID control to optimize HRI in power-assisted object manipulation was proposed. The PID control was admittance-based, and it reflected human user’s cognition in term of weight perception.

Intellipad: Intelligent Soft Robotic Pad for Pressure Injury Prevention

Mahsa Raeisinezhad, Nicholas Pagliocca, Behrad Koohbor and Mitja Trkov
Mechanical Engineering, Rowan University, NJ, USA

• Pressure injuries present significant health problems, and have a widespread occurrence.
• We present the mechanical characterization and control of soft robotic actuators to form a soft robotic pad.
• The actuators are designed to achieve independent horizontal and vertical motion to ameliorate tissue shear deformations at the ischial tuberosity, sacrum and the femur.
• Conducted experiments to verify finite element model displacements, and demonstrated redistribution of normal and shear loads.
Approximation of Covariance Matrices based on Matching Accuracy

Martin Rupp¹, Boris Blagojevic¹, Christian Knoll², Marc Patrick Zapf³, Zhang Weimin⁴ and Oliver Sawodny⁴.
¹University of Stuttgart
²Robert Bosch GmbH
³Bosch (China) Investment Ltd.
⁴Tongji University

• Improving Visual Servoing with UKF-based pose estimation by using a variable measurement covariance.
• Covariance approximation depends on the quality of pose estimation, which is obtained from image processing.
• The correlation between covariance and quality of pose estimation has been derived based on measurement data.

Sensing One Nanometer over Ten Centimeters: A Micro-Encoded Target for Visual In-Plane Position measurement

Antoine N. André¹, Patrick Sandoz¹, Benjamin Mauzé¹, Maxime Jacquot¹, Guillaume J. Laurent¹
¹FEMTO-ST Institute, Univ. Bourgogne Franche-Comté, Besançon, France

• 1 nm resolution / 10x10 cm² range
• Less than one thousands of a pixel
• 10⁸ range/resolution ratio
• Robust pose estimation process
  - Uneven lighting, poor contrast, etc.
  - Self-calibrating, >100Hz (256x256 px)
• Absolute, multi-DOF and cost-effective
  - Much more flexible than interferometers

Digital Image Correlation based on Primary Shear Band Model for Reconstructing Displacement, Strain and Stress Fields in Orthogonal Cutting

Yang Huang², Kok-Meng Lee*², Jingjing Ji¹, Wenjing Li²
¹SKL of Digi. Manuf. Equip. and Tech., Huazhong Univ. of Sci. and Tech., China
²Woodruff Sch. of Mech. Eng., Georgia Inst. of Tech., USA

• The extended DIC incorporates a material constitutive model to capture highly intensive localized elastic-plastic strain and stress fields during cutting.
• Verified by comparing with 1) simulated ground-truth, 2) AdvantEdge software, and 3) experiments.
• Experiments captured sudden velocity changes and localized strains/stresses.
• Results provide insights into process optimization, and benchmark validation of analytical/numerical cutting models.

Active stereo-vision 3D perception system for precise autonomous vehicle hitching

Michael Feller, Jae-Sang Hyun, and Song Zhang
Purdue University, West Lafayette, IN 47906

• Developed an affordable active 3D sensor
• Integrated the sensor and vehicle together for autonomous control
• Achieved an overall standard deviation of 3.0 mm of lateral error and 1.5° of angular error for a vehicle arriving from ±35°
A New Electromagnetic Actuation System with a Highly Accessible Workspace for Microrobot Manipulation

Ahmed Chah\textsuperscript{1}, Tarik Kroubi\textsuperscript{2}, Karim Belharet\textsuperscript{3}
\textsuperscript{1}INSA-CVL / HEI campus Centre, PRISME EA 4229, Châteauroux, France.
\textsuperscript{2}Université Mouloud Mammeri, PRISME EA 4229, Tizi-Ouzou, Algérie.
\textsuperscript{3}HEI campus Centre, PRISME EA 4229, Châteauroux, France

- System Design
- Magnetic Manipulation Platform
- Tests and Results

A Unified Knee and Ankle Design for Robotic Lower-Limb

Md Rejwanul Haque\textsuperscript{1}, Xiangrong Shen\textsuperscript{1}
\textsuperscript{1}Department of Mechanical Engineering, University of Alabama, Tuscaloosa, AL, USA

- Robotic knee prosthesis and ankle prosthesis have been treated as distinct, standalone devices, despite their common purpose of restoring joint functions.
- A new unified design approach is proposed.
- The unified Design restores joint functions while fulfilling their respective biomechanical requirements (torque, speed, range of motion, form factor etc.)

Compressed Gas Actuated Knee Assistive Exoskeleton for Slip-Induced Fall Prevention During Human Walking

Monika Mioskowska, Duncan Stevenson, Michael Onu, Mitja Trkov
Rowan University, USA

- Foot slip is a major cause for falls, especially among elderly populations.
- We present the development of a wearable knee assistive exoskeleton aiming to assist and prevent slip-and-falls.
- Device was designed to make use of small, lightweight parts and energy sources to achieve minimal activation time with minimal device weight.
- A novel active slip recovery control strategy is proposed, using this device to extend the trailing leg during the swing phase of a slip.
- Data is presented from benchtop characterization and preliminary human subject testing.

Vibration Analysis in Robot-Driven Glenoid Reaming Procedure

M. Faieghi\textsuperscript{1}, S. F. Atashzar\textsuperscript{2}, M. Sharma\textsuperscript{3}, O. R. Tutunea-Fatan\textsuperscript{3}, R. Eagleso\textsuperscript{3}, L. M. Ferreira\textsuperscript{3}
\textsuperscript{1}Toronto Rehabilitation Institute
\textsuperscript{2}New York University
\textsuperscript{3}Western University

- Empirical investigation of tool vibrations in the human glenoid reaming procedure, for the first time.
- A new experimentation approach using robot-driven trials.
- Time-domain and frequency-domain analysis of vibrations revealed the dominant frequencies and relations to predict vibrations using bone density and feed force.

(a) Surgical tool, (b) glenoid reaming, and (c) experiment setup.
Humanoid Robots
Chair Ye Zhao, Georgia Institute of Technology
Co-Chair Taskin Padir, Northeastern University

13:30–13:45 TuBT12.1

Generation of human-like gait adapted to environment based on a kinematic model
Miao Zhang1, and Ronglei Sun1,2
1State Key Laboratory of Digital Manufacturing Equipment and Technology, School of Mechanical Science & Engineering, Huazhong University of Science and Technology, Wuhan, Hubei Province, China

- Establish a kinematic model with gait features to generate human-like gaits.
- Propose a gait transition method among five common kinds of gaits.
- Generate the human-like gaits matching any 3D environment well.

14:00–14:15 TuBT12.3

Design of a Humanoid Bipedal Robot Based on Kinematics and Dynamics Analysis of Human Lower Limbs
Donghua Huang, Miao Z, Yong Li, and Taskin Padir, Senior Member, IEEE

This paper proposes a humanoid bipedal robot based on kinematics and dynamics analysis of human lower limbs. The overall structural design and the mechanism design of the bipedal robot is presented, and the accuracy of the results is validated through a real physical prototype.

13:45–14:00 TuBT12.2

Constant Length Tendon Routing Mechanism through Axial Joint
Divya Shah1,2, Alberto Parmiggiani1, Yong-Jae Kim3
1Italian Institute of Technology
2University of Genoa
3IRIM Lab, KOREATECH

- Concept idea, design and prototyping of a novel tendon routing mechanism through pronation-supination (forearm) joint for backdrivable robot arms.
- Routines for 4 wrist tendons simultaneously through a 1 DOF axial joint with range of ±180°.
- Exploits a moving pulley system to achieve constant length and thus, full decoupling between axial joint and tendon motions.

14:15–14:30 TuBT12.4

In-situ Terrain Classification and Estimation for NASA’s Humanoid Robot Valkyrie
Maozhen Wang, Murphy Wonsick, Xianchao Long and Taskin Padir
Northeastern University

- A RNN-based method is proposed and evaluated for terrain classification.
- A method to estimate the stiffness of unknown terrains is developed. The estimated results are verified by comparing calculated ankle torques using estimated parameters with measured ankle torques from sensors.

14:30–14:45 TuBT12.5

Recoverability Estimation and Control for an Inverted Pendulum Walker Model Under Foot Slip
Marko Mihailec1, Ye Zhao2, and Jingang Yi3
1Dept. of Mechanical and Aerospace Engineering, Rutgers University, USA
2Woodruff School of Mechanical Engineering, Georgia Tech, USA

- Two-mass linear inverted pendulum (LIP) model for slip dynamics with closed-form algebraic solutions
- The phase space was partitioned into safe, recoverable and fail-prone regions
- The recoverability and control strategies were analyzed and a center-of-mass (CoM) controller was introduced to maintain balance under foot slip

2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
Development of a Vacuum Suction Cup by Applying Magnetorheological Elastomers for Objects with Flat Surfaces

Peizhi Zhang¹, Mitsuo Kamezaki¹, Kenshiro Otsuki¹, Zhuoyi He¹, Hiroyuki Sakamoto², Shigeki Sugano¹
¹Waseda University
²Nippon Paint Holdings Co., Ltd

- The maximum suction force is 8 N
- The maximum weight ratio of ferromagnetic particles for our MRE is 75 %wt.
- The MRE suction cup can pick up objects with a flat surface, which shows their feasible applications on picking robots and wall-climbing robots.

A Driving Distance Extended Piezoelectric Actuator Using Multidriving Pads and Capacitive Patches

Jie-Lin Ho¹, Yu-Jen Wang¹, Yi-Bin Jiang²
¹Department of Mechanical and Electro-Mechanical Engineering, National Sun Yat-sen University, Kaohsiung, Taiwan, R.O.C.
²Department of Automatic Machine, HIWIN MIKROSYSTEM Corporation, Taichung, Taiwan, R.O.C.

- Long stroke linear piezoelectric actuators: phase distribution were analyzed by utilizing finite element method under various dimensions of driving electrodes.
- A pair of comb-shaped electrodes were integrated into the piezoelectric actuator as a capacitive position
- A digital filter based on Kalman filter was developed to predict the signal trend and suppress the noise.

ANFIS-Based System Identification and Control of a Compliant Shape Memory Alloy (SMA) Rotating Actuator

Nader A. Mansour¹,², Hangyeol Baek², Tae soo Jang², Bu hyun Shin³ and Youngshik Kim³.
¹Dept. of Mech. Eng., Benha Faculty of Eng., Benha Univ., Egypt.
²Electronics & Control Eng. Dept., Hanbat National Univ., Daejeon, South Korea.
³Dept. of Mech. Eng., Hanbat National Univ., Daejeon, South Korea.

- This paper presents Anfis-based modelling and control of a 1-DOF rotating actuator using SMA material.
- The driving circuit and feedback sensory system are embedded in the actuator.
- The actuator is suitable for compliant applications like bio-inspired and soft robotics.

Multi-Output Compliant Shape Memory Alloy Bias-Spring Actuators

S. Thomas, A. Thabuis, T. Martinez and Y. Perriard
Swiss Federal Institute of Technology Lausanne (EPFL)

- Redesign of the traditional bias-spring SMA linear actuator, where the actuator can now perform complex multi-outputs
- Simulation and validation of the behaviour of the complex smart actuators designed using topology optimization.
- Replace traditional multi-output actuators such as mandrels and 4-jaw grippers that require complex parts and assembly.
Modeling and Design of Mechatronic Systems I
Chair Shaohui Foong, Singapore University of Technology and Design
Co-Chair Hiroyuki ISHII, Waseda University

10:15–10:30 WeAT2.1 Novel Growing Robot with Inflatable Structure And Heat-Welding Rotation Mechanism
Yuki Satake¹, Atsuo Takanishi², Hiroyuki Ishii²
¹Waseda University, Tokyo, Japan
²Waseda University, and the Human Robotics Institute (HRI), Tokyo, Japan

• Point 1. We developed a novel tip growing robot with inflatable tube.
• Point 2. We use heat welding mechanism to create bending structure of the robot body.
• Point 3. The robot can grow in mid-air, turn around yaw axis on the ground and climb a wall by bending around the pitch axis.

10:45–11:00 WeAT2.3 Design and Validation of a Novel Leaf Spring Based Variable Stiffness Joint with Reconfigurability
Jiahao Wu, Zerui Wang, Wei Chen, Yaqing Wang, and Yun-hui Liu
Department of Mechanical and Automation Engineering,
The Chinese University of Hong Kong, Hong Kong, China

• A novel leaf spring based variable stiffness joint with reconfigurability is proposed to provide safer physical human-robot interaction (pHRI).
• The effective length of the spring can be adjusted by changing the position of the slider locating at the intersection between a straight rail and an arcuate rail.
• A reconfigurable number of leaf springs provide six different stiffness ranges.

11:00–11:15 WeAT2.4 Modeling on Meshing Surface of the Spherical Cam Transmission Mechanism in a Twin-rotor Piston Engine
Hu Chen¹, Qingkai Hou¹, Haijun Xu¹, Lei Zhang¹
¹National University of Defense Technology, Changsha 410073, China

• Point 1. The spherical cam transmission mechanism was studied, which is simple in structure, good in balance.
• Point 2. The parameter model of the cam profile was established with the enveloping surface theory, and the characteristics of the cam profile were analyzed.
• Point 3. The cam profile is a extended surface and conducive to process.

11:15–11:30 WeAT2.5 Hybrid Kinematics Modelling for an Aerial Robot with Visual Controllable Fluid Ejection
S.M. Lee, J.L. Chien, E. Tang, D. Lee, J. Liu, R. Lim, S. Foong
Engineering Product Development Pillar,
Singapore University of Technology and Design, Singapore

• A hybrid kinematics model is developed to determine the observed fluid ejection POC for any given altitude and distance-to-target.
• The study of non-linear fluid trajectory behavior through air is conducted to determine the fluid (drag) parameters.
• A visual compensation system is also developed to address for the presence of disturbances.
• The proposed method achieved an accuracy of 95.66%.
Aerial Robots I

Chair Hungsun Son, Ulsan National Institute of Science and Technology
Co-Chair Satoko Abiko, Shibaura Institute of Technology

10:15–10:30 WeAT3.1

Seamless 90-Degree Attitude Transition Flight of a Quad Tilt-rotor UAV under Full Position Control
Tomoyuki Magariyama and Satoko Abiko
Shibaura Institute of Technology, Japan

- This paper proposes a seamless attitude transition flight under the full position control.
- The thrust required to control the UAV is divided into a vertical component and a horizontal component and distributed to the control inputs.
- A flight experiment demonstrated that translational displacement was within ± 0.1 m at hovering during the seamless attitude change.

10:45–11:00 WeAT3.3

Concurrent Optimization of Mechanical Design and Control for Flapless Samara-Inspired Autorotating Aerial Robot
Shane Kyi Hia Win, Luke Soe Thura Win, Danial Sufiyan
Gim Song Soh and Shaohui Foong, Member, IEEE
Engineering Product Development, Singapore University of Technology & Design Singapore

- Using a thruster unit instead of a flap for direction control of samara-inspired autorotating UAV
- Use of genetic algorithm to concurrently find optimum mechanical configuration of thruster and control parameters for square cyclic control
- Simulated free-flight and controlled flight characteristics and real-life experimental drop test of mSAW prototype to find glide slope.

11:00–11:15 WeAT3.4

Design and Control of Multibody Multirotor for Faster Flight and Manipulation
Wonmo Chung
School of Mechanical, Aerospace and Nuclear Engineering, Ulsan National Institute of Science and Technology

- A novel multibody octorotor UAV is developed to increase the controllability and flight performance.
- Independent control of pitch angle is achieved without additional actuators such as servo motors.
- Aerodynamic analysis for validating an increase of maximum speed.

11:15–11:30 WeAT3.5

Generation and Control of Impulsive Forces by a Planar Bi-Rotor Aerial Vehicle through a Cable Suspended Mass
Prakhar Jain and Vivek Sangwan
Department of Mechanical Engineering, Indian Institute of Technology, Bombay

- Controlled impulse interaction by a swinging mass on a planar bi-copter to drive an initially stationary mass into a target hoop.
- Presented reasonable constraints and assumptions to generate trajectories using an optimization problem with linear constraints.
- Dynamic simulation with a controller demonstrating the maneuver.

2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
Proposal for Pipeline-Shape Measurement Method Based on Highly Accurate Pipeline Length Measurement by IMU Sensor Using Peristaltic Motion Characteristics

Hiroto Sato1, Yuki Mano1, Funmio Ito1, Member, IEEE, Takumi Yasui1, Manabu Okui1, Member, IEEE, Rie Nishihama1, and Taro Nakamura1, Member, IEEE
1Department of Precision Mechanics, Faculty of Science and Engineering, Chuo University

• Using peristaltic movements, which are characteristic of robots
• Makes it easier to identify the location of sewage pipe breaks
• Measurement of conduit geometry with IMU sensor only

Inverse Decoupling-based Direct Yaw Moment Control of a Four-wheel Independent Steering Mobile Robot

Liquan Jiang, Shuting Wang, Jie Meng, Xiaolong Zhang, Jian Jin, and Yuanlong Xie
School of Mechanical Science and Engineering, Huazhong University of Science and Technology

• The decoupling of steering drive system is realized
• An iterative fuzzy sliding mode controller is designed
• Experimental and simulation verify the validity of the method

Reaction-Wheel-Based Roll Stabilization for a Robotic Fish Using Neural Network Sliding Mode Control

Pengfei Zhang1,2, Z. Wu1,2, H. Dong1,2, M. Tan1,2, and Junzhi Yu1,3
1Institute of Automation, Chinese Academy of Sciences
2School of Artificial Intelligence, University of Chinese Academy of Sciences
3College of Engineering, Peking University

• Utilizing the reaction wheel on the attitude stabilization control of the robotic fish for the first time.
• Proposing a neural network sliding mode controller to reject the disturbance and maintain the roll stability.
• Demonstrating the superior performance of the proposed method compared with the stabilization method based on pectoral fins.

Provably Stabilizing Controllers for Quadrupedal Robot Locomotion on Dynamic Rigid Platforms

Amir Iqbal, Yuan Gao, Dr. Yan Gu
Department of Mechanical Engineering, University of Massachusetts Lowell

• Formulated the model of quadrupedal robot walking on a dynamic platform as a hybrid dynamical system
• Derived a control law that provably realizes stable locomotion on dynamic rigid platforms
• Validated the control law both through simulations and experimentally on a physical quadrupedal robot

Training End-to-End Steering of a Self-Balancing Mobile Robot Based on RGB-D Image and Deep ConvNet

Chih-Hung G. Li, Long-Ping Zhou
Graduate Institute of Manufacturing Technology
National Taipei University of Technology

• An end-to-end deep learning visual steering strategy was proposed for a self-balancing mobile robot.
• The deep learning scheme allows the system to imitate a human rider’s social-aware reactions in indoor corridor environments.
• Two types of navigation tasks - cornering and path adjustment are demonstrated; results are reported (https://youtu.be/a481aVdBkJk).

The proposed end-to-end steering system for a self-balancing mobile robot receives RGB-D inputs of the front view and predicts handlebar angle by a deep ConvNet.

2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
Failure State Estimation Using Soft Tactile Fingertip in Insertion Tasks

Muhammad Hisyam Rosle1, Koji Shiratsuchi2, and Shinichi Hirai1
1College of Science and Engineering, Ritsumeikan University, Japan
2Advanced Technology R&D Center, Mitsubishi Electric Corporation, Japan

- The failure state (FS) estimation during part insertion task is presented using soft tactile fingertip.
- The fingertip consists of two 3-axis Hall sensors, four cylindrical magnets, and silicon rubber.
- The control flow of FS estimation is proposed to be applied in robotic assembly.

3D Printed Soft Pneumatic Bending Sensing Chambers for Bilateral and Remote Control of Soft Robotic Systems

Charbel Tawk1,2, Marc in het Panhuis3,4, Geoffrey M. Spinks2,3, and Gursel Alici1,2
1School of Mechanical, Materials, Mechatronic and Biomedical Engineering, University of Wollongong, Australia
2ARC Centre of Excellence for Electromaterials Science
3Intelligent Polymer Research Institute
4School of Chemistry and Molecular Science, University of Wollongong, Australia

- Fabricated using an FDM 3D printer
- Advantages: fast response, linearity, negligible hysteresis, repeatability, stability and low power consumption
- Applications: Bilateral and remote control of robotic systems using wearable soft gloves

Toward Vision-based Adaptive Configuring of A Bidirectional Two-Segment Soft Continuum Manipulator

Jiewen Lai1, Kaicheng Huang1, Bo Lu2, Henry K. Chu1
1Dept. of Mechanical Engineering, The Hong Kong Polytechnic University
2CURI, The Chinese University of Hong Kong

- A two-segment cable-driven soft continuum manipulator can be reconfigured based on user-defined points on the image using visual servoing.
- This model-free method can allow the manipulator to maintain its posture while adjusting its stiffness to support different external loads.
- Experiments were conducted to confirm the performance of this method.

2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
In this study, we investigated to study control for the hydraulically actuated series actuators (HSEAs) targeted to heavy-duty applications. Nonlinear model based control design for the HSEAs with impedance control. The one degrees-of-freedom experimental setup is used to verify the control performance of the proposed controller.
Virtual-constraint-energy-based cooperative control method in flexible remote-control system of mobile manipulator

Yuta Naito¹ and Nobuto Matsuhira¹
¹Shibaura Institute of Technology

- We proposed a virtual-constraint-energy-based cooperative control method for remotely controlled robot operation.
- We conducted experiments that verified the influence of the method on reducing operability deterioration in remote environments due to delayed camera images resulting from communication delay.
- The virtual constraint energy changes relative to the magnitude of the communication delay and the distance between the robot and the object to be gripped. Next, we will improve the operability.

Hardware-In-the-Loop-Simulation of a Planar Manipulator with an Elastic Joint

S. Abiko¹, T. Kimura¹, Y. Noda¹, T. Tsujiya¹, D. Sato², and D. N. Nenchev²
¹Shibaura Institute of Technology, Japan
²Tokyo City University, Japan

- This paper presents a Hardware-In-the-Loop-Simulation (HILS) for a planar robot with an elastic joint.
- The motions of the HILS and the corresponding real manipulator were compared to evaluate the HILS performance for the robot with an elastic joint.
- The overall motion of the HILS could be in agreement with that of the real manipulator.

Data-driven Model Free Adaptive Control for an Omnidirectional Mobile Manipulator Using Neural Network

Chao Ren¹, Jingyi Zhang¹, Wei Li¹, Shugen Ma²
¹School of Electrical and Information Engineering, Tianjin University, Tianjin 300072, China
²Department of Robotics, Ritsumeikan University, Shiga 525-8577, Japan

- This paper presents a new control scheme for an OMM combining MFAC with neural network.
- A data model is derived based on pseudo partial derivatives and RBFNN. The weights of RBFNN are updated by concurrent learning.
- Simulations are conducted to verify the effectiveness and robustness of the proposed control design.
**Vehicle Control**

Chair Guodong Yin, Southeast University  
Co-Chair Yafei Wang, Shanghai Jiao Tong University

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### 10:15–10:30 WeAT8.1

**Acceleration comfort guaranteed ASR for distributed driving electric vehicle via gain-scheduled robust pole-placement**

Tong Shen\(^1\), Guodong Yin\(^1\), Yanjun Ren\(^1\), Jinxiang Wang\(^1\), Jinhao Liang\(^1\), Wenhan Sha\(^1,2\)

\(^1\)The authors are with the School of Mechanical Engineering, Southeast University, Nanjing, 211189, China  
\(^2\)The authors are with the Chery New Energy Vehicle Co. Ltd., Wuhu, 241100, China

- The tire lag provokes the oscillation of longitudinal acceleration  
- The lagged wheel dynamic model is more rationality for ASR design  
- Gain-scheduled robust pole-placement algorithm is adopted to improve the comfort of ASR and deal with the uncertainty of tire stiffness and velocity

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### 10:45–11:00 WeAT8.2

**Inter-target Occlusion Handling in Multi-extended Target Tracking Based on Labeled Multi-Bernoulli Filter using Laser Range Finder**

Kunpeng Dai\(^1\), Yafei Wang\(^1\), Jia-sheng Hu\(^2\), Kanghyun Nam\(^3\) and Chengliang Yin\(^1\)

\(^1\)School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai, China  
\(^2\)Department of Mechanical Engineering, National Cheng Kung University, Tainan City 701, Taiwan  
\(^3\)School of Mechanical Engineering, Yeungnam University Gyeongsan, South Korea

- Inter-target occlusion among multi-extended target tracking may lead to the problem of estimated trajectory break and even target loss. In this work, we propose an improved LMB filter with occlusion handling ability to tackle the problem. The effectiveness is verified through multiple vehicle tracking simulation and field test.

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### 10:15–11:30 WeAT8.3

**Estimation of Vehicle State Using Robust Cubature Kalman Filter**

Yan Wang\(^1\), Fengjiao Zhang\(^2\), Keke Geng\(^1\), Weichao Zhuang\(^1\), Haoxuan Dong\(^1\), Guodong Yin\(^1\)

\(^1\)School of Mechanical Engineering, Southeast University, Nanjing, China  
\(^2\)School of Vehicle Engineering, Changzhou Vocational Institute of Mechatronic Technology, Changzhou, China.

- 1. Accurate estimation of the vehicle state is quite significant for the advanced driver assistance system (ADAS).  
- 2. A robust cubature Kalman algorithm is proposed to estimate yaw rate, sideslip angle, and vehicle speed.  
- 3. Simulation and experimental tests results indicate that the proposed method has higher estimation accuracy than the existing method.

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### 11:00–11:15 WeAT8.4

**Feedforward for lateral trajectory tracking of automated vehicles**

Andreas Homann\(^1\), Markus Buss\(^2\), Martin Keller\(^2\), Torsten Bertram\(^1\)

\(^1\)TU Dortmund University, Institute of Control Theory and Systems Engineering  
\(^2\)ZF Group, Active & Passive Safety Technology

- Extension of mass point trajectories for automated driving functions by information of the vehicle dynamic state  
- Development of a feedforward control by inversion of the linear single-track model  
- Use of the estimated vehicle dynamic state in the course of the trajectory for flatness based feedforward control

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### 11:15–11:30 WeAT8.5

**Safety-Guaranteed Learning-Predictive Control for Aggressive Autonomous Vehicle Maneuvers**

Aliagshar Arab and Jingang Yi

Dept. Mechanical and Aerospace Engineering, Rutgers University, USA

- Developed an autonomous driving controller for aggressive vehicle maneuvers  
- The controller maximizes the safety region of vehicle maneuvers  
- Gaussian process model is used to improve the control performance  
- Sum-of-Square is used to estimate the safety boundary  
- Experimentally demonstrated on an indoor scaled vehicle testbed

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2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
### Disturbance Observer-Based Controller for Mimicking Mandibular Motion and Studying Temporomandibular Joint Reaction Forces by a Chewing Robot

**Authors:** Naser Mostashiri, Jaspreet S. Dhupia, Senior Member, IEEE, Alexander W. Verl, Member IEEE, Weiliang Xu, Senior Member, IEEE

**Abstract:**

The device has a built-in power source and control system. The device can be driven without using an external system. The first modularized device with variable viscoelastic properties is proposed.

- **Variable Viscoelastic Joint Module (VVE-JM)**

### Soil Transportation by Peristaltic Movement-Type Pump Inspired from the Lubrication System of the Large Intestine and Ceramic Art

**Authors:** Haruka Adachi1, Daisuke Matsui1, Kota Wakamatsu1, Daiki Hagiwara1, Masahiro Ueda2, Yasuyuki Yamada2, Taro Nakamura1

1Chuo University

2TAKENAKA CORPORATION

**Abstract:**

A new method of transporting sediment on construction sites is proposed. In the proposed method, the object of transportation itself is used as a lubricant. It was confirmed that the developed system is effective for low water content soil.

### Analysis and Validation of Serpentine Locomotion Dynamics of a Wheeled Snake Robot Moving on Varied Slope Environments

**Authors:** Jason Lim1, Weixin Yang1, Yantao Shen1, Jingang Yi2

1University of Nevada, Reno

2Rutgers, The State University of New Jersey

**Abstract:**

- Investigated motion dynamics for serpentine gait of wheeled snake-like robot on sloped environments.
- Winding angle parameter is primary factor affecting ability to move in sloped environments and has effects on speed that vary for different motion scenarios.
- Simulation and experimental results agree qualitatively.

### Bionic Sea Urchin Robot with Foldable Telescopic Actuator

**Authors:** Luis Guzman

**Abstract:**

A novel bionic sea urchin robot with foldable telescopic actuator is presented. The robot is capable of moving on varied slope environments.
Session WeAT10  Room T10  Wednesday, July 8, 2020, 10:15–11:30

Planning and Navigation I
Chair Yong Liu, Zhejiang University
Co-Chair Mahdi Hassan, University of Technology, Sydney

10:15–10:30  WeAT10.1

Squircular-CPP: A Smooth Coverage Path Planning Algorithm based on Squircular Fitting and Spiral Path

Mahdi Hassan¹, Dikai Liu¹, Xiang Chen²
¹Centre for Autonomous Systems (CAS) at the University of Technology Sydney
²Department of Electrical and Computer Engineering, University of Windsor

• Fit a Squircle (intermediate shape between circle and square) or Rectellipse (intermediate shape between rectangle and ellipse) to the target area
• Simple, fast, and analytical shape fitting not requiring a preselection of the shape (i.e. circle, square, ellipse or rectangle)
• Enables and complements the creation of a smooth spiral path within the fitted shape

Covering the target areas using Squircular-CPP

10:45–11:00  WeAT10.3

Cellular Decomposition for Non-repetitive Task Coverage Ensuring Least Discontinuities

Tong Yang, Jaime Valls Miro, Qianen Lai, Yue Wang, Rong Xiong
Robotic Laboratory, Zhejiang University
Centre for Autonomous Systems (CAS), University of Technology Sydney

10:30–10:45  WeAT10.2

A Dynamical System Approach to Real-time Three-Dimensional Concave Obstacle Avoidance

Dake Zheng¹,², Xinyu Wu¹, Yizhang Liu², and Jianxin Pang²
¹Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences
²UBTECH Robotics, Corp.

• A Dynamical System (DS) based approach to avoid three-dimensional concave obstacles in real-time is proposed;
• Most concave obstacles can be approximately divided into several intersecting convex ones;
• When a trajectory reaches a point on the intersection line between two convex ellipsoids, the trajectory evolves along the intersection line.

Illustration of avoiding a pedestrian which approximately composed of six ellipsoids.

11:00–11:15  WeAT10.4

Collision-free Trajectory Planning for Autonomous Surface Vehicle

Licheng Wen¹, Jiaqing Yan¹, Xuemeng Yang¹, Yong Liu¹
¹College of Control Science and Technology, Zhejiang University, Hangzhou, China

• Introduce a two-stage trajectory planning framework.
• Design two numerical objective functions which can optimize safe and fuel-saving trajectories.
• Perform experiments in Gazebo simulation to verify our method’s efficiency and accuracy.

Trajectory planning process

11:15–11:30  WeAT10.5

Path-Following with LiDAR-based Obstacle Avoidance of an Unmanned Surface Vehicle in Harbor Conditions

Jose Villa, Jussi Aaltoinen, and Kari T. Koskinen
Mechatronics Research Group (MRG), Tampere University (TAU), 33720, Tampere, Finland

• A simplified maneuvering model for a USV is developed based on field-test data.
• The obstacle avoidance uses a safety boundary box, providing fast decision-making capabilities due to its simplicity, low data transfer, and modular approach.
• The experimental results in two control scenarios (simulation and field-test) validate the designed GNC architecture.

Path-following with obstacle avoidance in simulation (a) and field-test (b) scenarios

2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
Rehabilitation Robots I
Chair Kok-Meng Lee, Georgia Institute of Technology
Co-Chair Muhammad Zahak Jamal, Hyundai Motor Company

10:15–10:30 WeAT11.1
A Novel Pantographic Exoskeleton based Collocated Joint Design with Application for Early Stroke Rehabilitation
Jiaoying Jiang1,2, Wenjing Li3, and Kok-Meng Lee2*
1Huazhong Univ. of Sci. and Tech., Wuhan Hubei 430074, China
2Woodruff Sch. of Mech. Eng., Georgia Inst. of Tech., Atlanta, GA 30332-0405, USA

• The 3-DOF pantographic exoskeleton (PGE), which is collocated with the impaired joint to avoid accidental injuries, traces the natural joint motion "like a pantograph" for in-bed exercises.
• Derived a physics-based ankle-imb/PGE-link kinematic model, and its Jacobian matrix to serve as a joint-force index; and analyzed different designs involving serial mechanism, collocated-PGE and bio-joint.
• Experimentally determined the slide-to-roll ratio $\eta$ (commonly neglected in published literatures) of an ankle-joint with the PGE, and validated with that estimated using an analytical model with CT parameters.

10:45–11:00 WeAT11.2
Reconfigurable Impedance Sensing System for Early Rehabilitation following Stroke Recovery
Jingjing Ji1*, Yiyuan Qi1, Jiahao Liu1 and Kok-Meng Lee2*
1School of Mech. and Sci., Huazhong Univ. of Sci. and Tech., China
2 George W. Woodruff School of Mech. Eng., Georgia Inst. of Tech., USA

• A reconfigurable impedance sensing system integrating force, displacement and impedance sensing is proposed, which is designed, rapidly prototyped, fabricated and experimentally verified.
  a) In the sensor model, the magnet, electrometer and the hall sensor constitute the equivalent impedance model, which is distributed in the flexible platform to obtain the distributed force and displacement, and
  b) In the rapid prototyping, a 3D rapid prototyping mold is used to pour recyclable rubber and solidify the mold at room temperature.
  c) In the sensor performance test, both force and deformation are simultaneously measured through the experiment.

11:00–11:15 WeAT11.3
Gait Assessment on EMG and Trunk Acceleration with Impedance-Controlled Gait-Aid Walker-Type Robot
Watanabe Shun, Tsumugiwa Toru and Yokogawa Ryuichi
Biomedical Engineering, Doshisha Univ., Japan

• We assessed effects of difference in impedance parameters on EMG of lower-extremity and gait performance.
• Six healthy men were asked to walk speed with restriction of right knee joint movement.
• Effects were not confirmed in range of impedance parameters set presented in this experiment.

11:15–11:30 WeAT11.4
Lower-Body Walking Motion Estimation Using Only Two Shank-Mounted Inertial Measurement Units (IMUs)
Tong Li1, Lei Wang1, Qingsuo Li2, Tao Liu2*
1School of Mechanical Engineering, Zhejiang University, China
2 Department of Mechanical and Materials Engineering, Queen's University, Canada

• we explore the feasibility of lower-body gait measurement using only two IMUs.
• A whole-step optimization approach is then used to estimate the lower-body motion.
• RMSE of lower-body joint angle estimation is 5.70°~7.68° degrees.
• Estimation accuracy is similar to systems using four or more IMUs

2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
Fault and Anomaly Detection
Chair Marko Mihalec, Rutgers University
Co-Chair Pratap Bhanu Solanki, Michigan State University

10:15–10:30 WeAT12.1
Defect detection based on singular value decomposition and histogram thresholding
Tran Xuan-Tuyen¹, Tran Hiep Dinh¹, Ha Vu Le¹, Qiuchen Zhu², Quang Ha²
¹University of Engineering and Technology, Vietnam National University Hanoi
²School of Electrical and Data Engineering, University of Technology of Sydney
A hybrid method integrating singular value decomposition (SVD) into histogram thresholding has been proposed:
• The effectiveness of SVD for emphasizing crack pixels has been verified via a bi-modal histogram of crack blocks
• The proposed SN-Otsu technique has improved the binarization results compared with other related thresholding techniques

10:30–10:45 WeAT12.2
Robust Fault Detection and Estimation of Sensor Fault for Closed-loop Control Systems
Yang Zhang¹, Shaoping Wang², Jian Shi²
¹School of Energy and Power Engineering, Beihang University
²School of Automation Science and Electrical Engineering, Beihang University
• Residual generation based on UIO with open-loop model.
• Residual compensation based on the closed-loop model.
• Fault identification of sensor gain.

10:45–11:00 WeAT12.3
Detecting wear in internal gear pumps by observing the pressure reduction time
Kurt Pichler¹, Rainer Haas², Veronika Putz¹, Christian Kastl¹
¹Area Sensors & Communication, Linz Center of Mechatronics GmbH
²Area Drives, Linz Center of Mechatronics GmbH
• Wear of internal gear pumps should be detected as early as possible to plan maintenance intervals
• In a data-driven approach, the wear is found to be correlated to the time of a certain pump pressure drop when the pump is stopped and all valves are closed
• This approach is more sensitive to upcoming wear than other well known approaches (pressure holding speed,...)

11:00–11:15 WeAT12.4
Hybrid Simulated Annealing and Genetic Algorithm for Optimization of a Rule-based Algorithm for Detection of Gait Events in Impaired Subjects
Juan C. Perez-Ibarra¹, Adriano A. G. Siqueira¹, Marco H. Terra¹, Hermano I. Krebs²
¹University of Sao Paulo, School of Engineering of Sao Carlos, Brazil
²Massachusetts Institute of Technology, USA
• An algorithm that uses a set of threshold-based rules to detect in real-time the transition among gait phases.
• A hybrid meta-heuristic approach that integrates GA and SA to compute sub-optimal combinations of those values.
• Results using IMU data during walking for one healthy, one hemiparetic, and one myelopathic subject obtaining F1-scores of 0.98, 0.99, and 0.91, respectively.
Student Design Competition Session

Chair Tao Liu, Zhejiang University
Co-Chair

10:15–12:20 WeSD.1

Acquisition and Processing of Multiple Human Body and Working Environment Signals Based on Wearable Sensor Network

Xiangzhi Liu¹, Yisong Li¹
School of Mechanical Engineering, Zhejiang University, Zhejiang, China

- Point 1. Obtain human motion information and environmental information through three IMUs and one radar
- Point 2. Has both wired and wireless transmission schemes
- Point 3. Use neural network algorithm to improve the accuracy of motion pattern recognition

10:15–12:20 WeSD.2

Turbo Micromouse – the Smart Maze Navigating Robot with a Suction Fan

Yingshu Liu, He Liu, Lei Wang, Guo Cheng
School of Electrical and Information Engineering, Tianjin University

- Mobile Robots
- Planning and Navigation
- Opto-Mechatronics Sensors

10:15–12:20 WeSD.3

Vision-based Autonomous Driving Robot Capable of Navigating in Unknown and Dynamic Rural Environments

Ramiz Hanani¹, David Pierce Walker-Howell¹, Leo Peralta¹
Advisors: Junfei Xie¹ (Faculty), Baoqian Wang¹ (Ph.D. Student)
¹San Diego State University

This project designs a mobile robot that can navigate autonomously in both urban and rural environments, which consists of three core modules:

- Sensing and perception module that uses IMU and encoders for pose estimation, and camera for environment perception.
- Planning module that leverages historical knowledge to achieve online path planning and adopts deep reinforcement learning for motion planning.
- Control module that achieves mobility control of the robot.

10:15–12:20 WeSD.4

Autonomous Scaled Race-Car Platform for Safe Aggressive Vehicle Maneuvers (RU-Racer)

Alborz Jelvani, Dimitri Duma, Aliasghar Arab, Kuo Chen, Jiaxing Yu, and Jingang Yi
Dept. of Mechanical and Aerospace Engineering, Rutgers University, USA

- Designed and fabricated a scaled racing car testbed for autonomous aggressive vehicle maneuvers
- Custom tracking system for live motion data with live visualization in web-interface
- Implementation of NVIDIA Jetson TX2 Linux system with Robot Operating System (ROS) for on-board computing system
- Tested and demonstrated the vehicle performance for motion planning and control algorithms

10:15–12:20 WeSD.5

Development of a Bikebot with Mobile Manipulator for Evaluation and Intervention Systems for Densely-Grown Horticultural Crops

Alborz Jelvani, Merrill Edmonds, Yongbin Gong, and Jingang Yi
Dept. of Mechanical and Aerospace Engineering, Rutgers University, USA

- Two-wheel steering self-balancing electric bike with 6-DOF manipulator arm for crop inspections via multi-camera suite
- Implementation of custom embedded system for real-time balance, steering, and velocity control
- Use of Robot Operating System (ROS) and MoveIt! for end-effector control and bikebot navigation
- Tested and implemented for balancing and imaging systems in indoor lab

10:15–12:20 WeSD.6

AIM2020 Student Design Competition Proposal Multimodal Tactile Sensing Glove

Togzhan Syrymova, Karina Burunchina, Valeriy Novossyolov, Saltanat Seitzhan, and Zhanat Kappassov
¹Robotics Dept., Nazarbayev University, Kazakhstan

- Multi-modal tactile glove
- Two vibro-tactile sensors for detecting granular objects
- 27 pressure sensors for static contacts
- Goal is to detect foreign bodies similar to breast inspection

2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
Piezoelectric Device for Inducing Strain on Cell Samples

Team: Nicholas Carlisle\(^1\), Siddarth Venkatesh\(^1\), Andrew Yeo\(^1\)

Supervisors: Ebubekir Avcı\(^1\), Samuel Rosset\(^2\)

\(^1\)Department of Mechatronics, Massey University, New Zealand
\(^2\)Auckland Bioengineering Institute, University of Auckland, New Zealand

- A piezo actuated tissue stretching mechanism is designed to simulate mechanotransduction in brain and cardiac muscle tissue in vitro environment (under microscope).
- We have implemented an amplification mechanism to overcome the workspace limitation of piezo actuators.
- We have simulated workspace and max stress condition to optimize the proposed system.

Exploiting Quasi-Direct Drive Actuation in a Knee Exoskeleton for Effective Human-Robot Interaction

Peter Phung, Sainan Zhang, Hao Su

Department of Mechanical Engineering, The City University of New York, City College, NY, 10023, US

A subject wearing the prototype of the vacuum-driven soft wearable robot for ankle assistance; The pneumatic actuator can reach 300 N when subjected to a pressure of 30 kPa.
Multi-station and multi-robot welding path planning based on greedy interception algorithm

Zhao Guangbao¹, Wu Jianhua²
¹e-mail: zhaoguangbao@sjtu.edu.cn
²phone: 021-34290547 e-mail: wujh@sjtu.edu.cn

• This paper investigates the multi-station and multi-robot coordinated welding task
• The multi-constraint optimization problem is divided into four parts to reduce the complexity
• Grouping algorithm based on distance ratio and heuristic interception distribution algorithm are proposed to ensure the balance of welding tasks
• Simulation results have verified the efficacy of the proposed method

Development of an Autonomous Soldering Robot for USB Wires

Yuan Gao, Zhi Chen, Mengjun Fang, Yun-Hui Liu and Xiang Li
The Chinese University of Hong Kong
Tsinghua University

• A new autonomous robot is developed to fully automate the whole procedure of soldering of USB wires, including all the pre-processing steps.
• A series of novel mechanisms are designed and implemented to deal with the deformation of wires.
• The developed robot has the advantage of highly autonomous capability, in the sense that no human assistance or supervision is required throughout the procedure.

Robotic Wire Pinning for Wire Harness Assembly Automation

E. Tunstel¹, A. Dani², C. Martinez², B. Blakeslee³, J. Mendoza³, R. Saltus², D. Trombetta², G. Rotithor³, T. Fuhlbrigg³, D. Lasko³, J. Wang³
¹Raytheon Technologies Research Center, East Hartford, CT USA
²University of Connecticut, Storrs, CT USA
³ABB, Inc., US Corporate Research, Bloomfield, CT USA

• Integrated system for small wire pinning component manipulation and assembly
• Robotic intelligence: trajectory learning and vision-guided small part insertion
• Automated fine manipulation and tool use

Key Ingredients for Improving Process Quality at High-Level Cyber-Physical Robot Grinding Systems

Chih-Hsuan Shih¹,²,³, Yuan-Chieh Lo³, Hsuan-Yu Yang²,³ and Feng-Li Lian²,³
¹Department of Computer Science and Information Engineering, National Taiwan University, Taipei, Taiwan.
²Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan.
³Mechanical and Mechatronics System Research Laboratories, Industrial Technology Research Institute, Hsinchu, Taiwan.

• A cyber-physical robot grinding system is proposed to increase efficiency, improve quality and save human effort.
• It consists of robot trajectory generation and modification, grinding machine localization and abrasive belt wear-life analysis.
• The tuning time is shortened to 1-2 days.

Robotic intelligence: trajectory learning and vision-guided small part insertion

Software flowchart of Cyber-Physical Robot System.

Concrete curing setup
Control of Mechatronic Systems I
Chair Aaron Hunter, University of California, Santa Cruz
Co-Chair Shafiqul Islam, Xavier University of Louisiana

13:30–13:45 WeBT2.1
LQR Feedback Linearization Method to Control the Motions of a Spherical Serial Mechanism
Meziane Larbi, Karim Belharet, El-Hadi Guechi
Meziane Larbi and El-Hadi Guechi are with Laboratoire d’Automatique de Skikda, Université 20 Août 1955, SKIKDA 21000, Algérie.
Karim Belharet is with Laboratoire PRISME EA 4229, HEI campus Centre, Châteauroux, France

14:00–14:15 WeBT2.3
Dynamics and Isotropic Control of Parallel Mechanisms for Vibration Isolation
Xiaolong Yang1, Hongtao Wu1, Yao Li1, Shengzheng Kang1, Bai Chen1, Huimin Lu2, Carman. K. M. Lee3, and Ping Ji3
1Nanjing University of Aeronautics and Astronautics, CHN
2Kyushu Institute of Technology, JP
3Hong Kong Polytechnic University, HK

13:45–14:00 WeBT2.2
A Crossover Network based Control Concept for the Tip-Tilt Rejection in METIS
Philip L. Neureuther1, Thomas Bertram2, Oliver Sawodny1
1Institute for System Dynamics, University of Stuttgart, Germany
2Max Planck Institute for Astronomy, Heidelberg, Germany

14:15–14:30 WeBT2.5
Bicycle Wheel System Identification and Optimal Truing Control for Mechatronic Systems
Aaron Hunter1
1University of California, Santa Cruz

14:30–14:45 WeBT2.4
Modeling and Control of Fuel Cell Power System with Varying Load and Temperature
Shafiqul Islam
Xavier University of Louisiana, 1 Drexel Drive, Box 28, LA 70125.

- Develop model for Fuel Cell Power System
- Develop control system nonlinear Fuel Cell Power System
- Analyze fuel influence of the temperature on the Fuel Cell Power System and Temperature
- Analyze employed to control the hydrogen, oxygen and water vapor flow rate by regulating the methane flow rate of the gas reformer.
- Examine dynamic phenomenon of PEMFC power system in the presence of the sudden changes in the load and stack temperature
- Evaluate the proposed model and controller on a 5KW PEMFC power system to analyze the impact of the load and temperature variation on the output voltage.
Aerial Robots II
Chair Tarik Yigit, Rutgers University
Co-Chair Demetris Coleman, Michigan State University

13:30–13:45 WeBT3.1
Modeling, Identification, and Control of Non-minimum Phase Dynamics of Bi-copter UAVs
Yihang Li, Youming Qin, Wei Xu, Fu Zhang
Mechatronics and Robotics Systems (MaRS) Laboratory, Department of Mechanics Engineering, The University of Hong Kong

14:00–14:15 WeBT3.3
Fault tolerance analysis for a class of reconfigurable aerial hexarotor vehicles
Claudio D. Pose, Juan I. Giribet, and Ignacio Mas
1LAR, Facultad de Ingeniería, Universidad de Buenos Aires, Argentina
2Instituto Argentino de Matemática Alberto P. Calderón – CONICET, Argentina
3Instituto Tecnológico de Buenos Aires (ITBA), Argentina

13:45–14:00 WeBT3.2
Laboratory Method for Evaluating the Pointing Stability of two degrees of freedom gyroscopic stabilizers
Mohammad Sadegh Mirzazandi Darestani, Parviz Amir
1PhD candidate at Islamic Azad University, Arak, Iran
2Associate Professor of Electrical Engineering at Shahid Rajaei Teacher Training University, Tehran, Iran

14:15–14:30 WeBT3.4
Ground Trajectory Control of an Unmanned Aerial-Ground Vehicle using Thrust Vectoring for Precise Grasping
Shatatdal Mishra, Karishma Patnaik, YiZhuang Garrard, Zachary Chase, Michael Ploughe, Wenlong Zhang
1Arizona State University, USA
2Salt River Project, USA

14:30–14:45 WeBT3.5
Control of Multiple Quadcopters with a Cable suspended Payload Subject to Disturbances
Keyvan Mohammadi, Shahin Sirouspour, Ali Grivani

14:00–14:15 WeBT3.3
Fault tolerance hexarotor with fixed structures have limited maneuverability.
• Proposed reconfigurable structures for common hexarotor distributions improve maneuverability in case of a failure in one of the rotors.
• Experimental validation shows improved performance of proposed modifications.

13:45–14:00 WeBT3.2
Laboratory Method for Evaluating the Pointing Stability of two degrees of freedom gyroscopic stabilizers
Mohammad Sadegh Mirzazandi Darestani, Parviz Amir
1PhD candidate at Islamic Azad University, Arak, Iran
2Associate Professor of Electrical Engineering at Shahid Rajaei Teacher Training University, Tehran, Iran

14:15–14:30 WeBT3.4
Ground Trajectory Control of an Unmanned Aerial-Ground Vehicle using Thrust Vectoring for Precise Grasping
Shatatdal Mishra, Karishma Patnaik, YiZhuang Garrard, Zachary Chase, Michael Ploughe, Wenlong Zhang
1Arizona State University, USA
2Salt River Project, USA

14:30–14:45 WeBT3.5
Control of Multiple Quadcopters with a Cable suspended Payload Subject to Disturbances
Keyvan Mohammadi, Shahin Sirouspour, Ali Grivani

• Passivity-based control scheme is proposed for cooperative transportation.
• Semi-Global Stability is shown with no assumption on the status of cables tension.
• A novel disturbance energy observer is proposed.
• Complementary controller is designed to suppress disturbance-induced oscillations.
• Experimental verifications are reported.
Planning and Control of Robotic Systems

Chair Zheng Chen, Zhejiang University
Co-Chair Xuebo Zhang, Nankai University,

13:30–14:15 WeBT4.1 A Hybrid Analytical and Data-driven Modeling Approach for Calibration of Heavy-duty Cartesian Robot
Hongyu Wan, Silu Chen, Yisha Liu, Chaochao Jia, Furu Jin, Jin Wang, Chi Zhang, Guilian Yang
Zhejiang Provincial Key Lab of Robotics and Intelligent Manufacturing Equipment Technology, Ningbo Institute of Materials Technology and Engineering, Chinese Academy of Sciences, Ningbo, China 315201

- The analytical BD model is built to remove the deformation error under the external load after geometric compensation.
- A data-driven GPR model is built to further reduce the residual error.
- Calibration results show the accuracy is now invariant to load.

14:00–14:15 WeBT4.3 Adaptive Sliding Mode Control Design for Nonlinear Unmanned Surface Vessel With Fuzzy Logic System and Disturbance-Observer
Yougong Zhang, Zheng Chen, Yong Nie, Jianzhong Tang, Shiqiang Zhu
Ocean College, Zhejiang University
The State Key Laboratory of Fluid Power and Mechatronic Systems, Zhejiang University

- A nonlinear dynamic model for USV is established.
- The modeling uncertainties and external disturbance can be estimated by fuzzy logic system and disturbance observer.
- The proposed control design is more suitable for any desired trajectory.

14:30–14:45 WeBT4.5 Adaptive Robust Control of Fully Actuated Bipedal Robotic Walking
Yan Gu, Chengzhi Yuan
1Department of Mechanical Engineering, University of Massachusetts Lowell, Lowell, MA, U.S.A.
2Department of Mechanical, Industrial and Systems Engineering, University of Rhode Island, Kingston, RI, U.S.A.

- Extended the construction of multiple Lyapunov functions with control Lyapunov function for designing controllers for hybrid systems with state-triggered jumps.
- Demonstrated the effectiveness of the proposed control approach through simulations on a 3-D bipedal robot with nine revolute joints.

13:45–14:00 WeBT4.2 A Reinforcement Learning Based Multiple Strategy Framework for Tracking a Moving Target
Zixuan Huo, Shilong Dai, Mingxing Yuan, Xiang Chen, Xuebo Zhang
1Institute of Robotics and Automatic Information System, Tianjin Key Laboratory of Intelligent Robotics, Nankai University, Tianjin 300071, China.
2Department of Electrical and Computer Engineering, University of Windsor, Ontario, Canada, N9B3P4.

- A hierarchical framework in which the proximal policy optimization in the upper level selects an appropriate strategy from the lower level to track a moving target is proposed.
- The proposed method is robust to environment variations.

14:15–14:30 WeBT4.4 Deterministic Learning with Probabilistic Analysis on Human-Robot Shared Control
Xiaotian Chen, Paolo Stegagno, Chengzhi Yuan
1Department of Mechanical, Industrial and Systems Engineering, University of Rhode Island, Kingston, RI, U.S.A.
2Department of Electrical, Computer and Biomedical Engineering, University of Rhode Island

- Deterministic Learning combines with probabilistic analysis to recognize the human gestures.
- Using recognition results to command a real robot.
- Using shared control to better improve the vehicle’s motion.

2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
Antecedent Redundancy Exploitation in Fuzzy Rule Interpolation-based Reinforcement Learning
Dávid Vincze\textsuperscript{1,2}, Alex Tóth\textsuperscript{2}, Mihoko Niiitsuma\textsuperscript{1}
\textsuperscript{1}Chuo University, Department of Precision Mechanics, Tokyo, Japan
\textsuperscript{2}University of Miskolc, Department of Information Sciences, Miskolc, Hungary

- Extension of Fuzzy Rule Interpolation-based Q-learning (FRIQ-learning)
- Novel strategies for further reducing the rule-bases constructed by FRIQ-learning
- Goal is to identify and remove redundant antecedents in fuzzy rules
- Results with common RL benchmarks demonstrate the efficiency of these new methods

Towards accelerated robotic deployment by supervised learning of latent space observer and policy from simulated experiments with expert policies
Olivier Algoet\textsuperscript{1,2}, Tom Lefebvre\textsuperscript{1,2}, Guillaume Crevecoeur\textsuperscript{1,2}
\textsuperscript{1}Dept. of Electromechanical, Systems and Metal engineering
\textsuperscript{2}EEDT-Decision & Control Flanders Make

- A novel sim2real architecture for converting simulated low level sensor data policies to high level real world policies
- A regularized autoencoder with reconstruction and policy specific gradients is purposed
- Pick and place task as proof of concept

Efficient Sampling for Rapid Estimation of 3D Stiffness Distribution via Active Tactile Exploration
Shiyi Yang, Soo Jeon and Jongeon Cho
\textsuperscript{1}Mechanical and Mechatronics Engineering, University of Waterloo, Canada
\textsuperscript{2}Mechanical Engineering, Yonsei University, Korea

- Estimation of stiffness distribution over 3D objects
  - Estimation of inhomogeneous stiffness distribution
  - Gaussian process regression
  - Optimal sample point selection strategy
  - Estimation with a limited number of sample points
  - Balance exploration and exploitation
  - Self-tuning weighting factor
  - Overall stiffness distribution
  - Extreme stiffness areas (low/high stiffness areas)
Micro and nano positioning
Chair Juan Ren, Iowa State University
Co-Chair Tong Zhang, University of Windsor

13:30–13:45 WeBT6.1
Modeling and Control of a Six-Axis Parallel Piezo-Flexural Micropositioning Stage With Cross-Coupling Hysteresis Nonlinearities
Shengzheng Kang, Hongtuo Wu, Shenglong Yu, Yao Li, Xiaoliang Yang, and Jiafeng Yao
College of Mechanical and Electrical Engineering, Nanjing University of Aeronautics and Astronautics, China

1. A six-axis parallel piezo-flexural micropositioning stage is designed.
2. The nonlinear hysteresis of the stage is characterized by a fractional-order normal Boush Wen (FOWBN) model.
3. A decentralized control strategy with an inverse-FOWBN-based hysteresis compensator is developed to make the MIMO system decoupled directly in the task space.
4. Experimental results validate the effectiveness of the proposed controller.

Optimal Reference Allocation of Dual-Stage Measuring Machines
Michael Ringkowski¹, Eckhard Arnold¹, Oliver Sawodny¹
¹Institute for System Dynamics, University of Stuttgart

1. Dual-stage optimal reference allocation considering coupling flexibilities
2. Optimization based design guidelines for fast axes
3. 2-DOF add-on MPRA for the closed loop axes control systems:
   - offline: compute optimal references
   - online: feedback MPRA in error coordinates compensates for errors
4. Simulation results validate the approach

Discrete System Linearization using Koopman Operators for Predictive Control and Its Application in Nano-positioning
Shengwen Xie¹, Juan Ren¹
¹Department of Mechanical Engineering, Iowa State University, Ames, IA 50010, USA

1. Compared to linearization based on Taylor series, Koopman approach is more accurate over the future N sampling instances making it more suitable for predictive control.
2. The order of the original system can be reduced to improve the computation efficiency of the predictive controller.

Adaptive Sliding-Mode H∞ Control via Self-Evolving Function-Link Interval Type-2 Petri Fuzzy-Neural-Network for XY-Stage Nonlinear System
Fayez F. M. El-Sousy¹, Mahmoud M. Amin², Ghada A. Abdel Aziz³, Osama A. Mohammed⁴
¹Prince Sattam bin Abdulaziz University, EE Department, Saudi Arabia
²Manhattan College, ECE Department, USA
³Electronics Research Institute, Egypt
⁴Florida International University, ECE Department, USA

1. An ASMHC is designed for accurate control of XY-stage nonlinear system.
2. The SEIT2LFNN estimator is used to approximate the uncertain dynamics.
3. The adaptive laws are derived using Lyapunov theorem and H∞ control.
4. The experimental results confirm the robust adaptive control performance under compounded disturbances.

Discrete-Time Repetitive Control with a Range-Based Filter for Dual-Stage Systems
Aleksandra Mitrovic¹, Kam K. Leang², and Garrett M. Clayton¹
¹Department of Mechanical Engineering, Villanova University, Villanova, PA, USA, garrett.clayton@villanova.edu
²Department of Mechanical Engineering, University of Utah, Salt Lake City, UT, USA, kam.k.leang@utah.edu

1. Range-based control (RBC) with repetitive control (RC) for tracking periodic trajectories in dual-stage nanopositioners is presented.
2. RBC+RC is compared to frequency-based control (FBC) and RBC without RC.
3. Results show the RBC+RC approach achieves lower error than the other two methods.

2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
Learning-Based Gravity Estimation for Robot Manipulator Using KRR and SVR
Chenglong Yu¹, Zhiqi Li², Hong Liu¹, Member, IEEE, Alan F. Lynch³, Member, IEEE
¹State Key Laboratory of Robotics and System, Harbin Institute of Technology
²Applied Nonlinear Controls Lab, Department of Electrical and Computer Engineering, University of Alberta
³University of Alberta

- A learning-based regression algorithm to estimate the gravity parameters
- Time-efficient kernel trick used with randomly located joint sampling data
- KRR and SVR regression techniques were introduced and compared

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Redundancy-Based Visual Tool Center Point Pose Estimation for Long-Reach Manipulators
Petri Mäkinen¹, Pauli Mustalathi², Sirpa Launis², Jouni Mattila¹
¹Tampere University, Tampere, Finland
²Sandvik Mining and Construction, Tampere, Finland

- Conceptual visual sensor system utilizing SLAM and marker-based tracking.
- Target application: Long-reach underground manipulators (e.g. tunnel jumbos, drill rigs).
- Experimental results based on a laboratory installed test setup.

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Calibration Methods for High Precision Robot Assisted Industrial Automation
Toufik A Khawli Shafiqul Islam
Xavier University of Louisiana, 1 Drexel Drive, LA 70125.

- Develop calibration methods for high precision robot assisted industrial automation process.
- Methods considers two calibration procedures based on both iterative and optimization solvers.
- Methods validated in a robotic simulation and experimental environment to visualize the transformations before and after calibration.
- Results show that the two calibration solvers are able to detect the exact poses from a simulated and experimental data sets with and without the effect of noise.

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Model-Based Manipulation of Linear Flexible Objects with Visual Curvature Feedback
Peng Chang¹, Taskin Padir²
¹College of Engineering, Northeastern University, Boston, Massachusetts, USA.
²Institute for Experiential Robotics, Northeastern University, Boston, Massachusetts, USA.

- Developed a novel 3D geometrical model of the linear flexible objects based on 2D models on two projection planes and learned object positions
- Validated a linear flexible object manipulation task (DRC Plug Task) using an autonomous system framework and a robust pose alignment controller
Multi-agent Systems
Chair Chengzhi Yuan, University of Rhode Island
Co-Chair Zhenhua Xiong, Shanghai Jiao Tong University

13:30–13:45 WeBT8.1

New Results on Cooperative Multi-Vehicle Deterministic Learning Control: Design and Validation in Gazebo Simulation
Xiaonan Dong¹, Xiaotian Chen¹, Chengzhi Yuan, Paolo Stegagno ²
¹Department of Mechanical, Industrial and Systems Engineering, University of Rhode Island
²Department of Electrical, Computer, and Biomedical Engineering, University of Rhode Island

- An online cooperative adaptive neural network (NN) learning control law is developed for trajectory tracking with a group of unicycle-type vehicles.
- An experience-based controller is developed using the converged NN models obtained from the learning control process.
- Simulation is run on Gazebo to validate performance of the proposed approach.

14:00–14:15 WeBT8.3

Synchronization of Distributed Generators (DG) in a Microgrid (MG) under Communication Latency
Himadri Basu, Se Young Yoon, Nicholas Kirsch, Michael Carter
Department of Electrical and Computer Engineering, University of New Hampshire, Durham, NH 03824, USA

- When the microgrid islands from the utility grid, the transient voltage and frequency instability is further worsened by the presence of large network delays.
- To achieve satisfactory synchronization control for the group of DGs, a consensus based cooperative voltage and frequency control protocol is developed, in which the effects of communication delays are considered.
- Sufficient delay dependent stability conditions and an upper bound for the low gain parameter were derived to ensure the stability of the synchronization in the face of any arbitrarily large bounded communication delays.

14:30–14:45 WeBT8.5

Finite-time formation control for multi-agent systems underlying heterogeneous communication typologies
Haopeng Zhang¹ and Sanka Liyanage²
¹ Department of Mechanical Engineering, University of Louisville, Louisville, KY, USA
² Department of Mechanical Engineering, Texas Tech University, Lubbock, TX, USA

- Formation control for multi-agent system was developed.
- Different topologies were studied:
  - velocity topology is not necessarily connected.
- Topology optimality will be studied in the future research by considering the tradeoff between convergence rate, control cost.

13:45–14:00 WeBT8.2

Leader-following formation control of nonholonomic mobile robots with velocity observers
Xinwu Liang¹, Hesheng Wang¹, Yun-Hui Liu², Zhe Liu², Weidong Chen¹
¹Shanghai Jiao Tong University, Shanghai, China
²The Chinese University of Hong Kong, Hong Kong, China

- Observers were designed to provide online estimation of the leader velocity.
- Several formation controllers based on velocity feedforward were proposed.
- Stability analysis was given to show the closed-loop stability of the observer-controller system.
- The proposed controllers can be implemented without measurement and communication of the leader velocity.

14:15–14:30 WeBT8.4

Distributed multi-robot formation control under dynamic obstacle interference
Jiawei Hu, Jiaze Sun, Zhengyang Zou, Diwei Ji, Zhenhua Xiong
Shanghai Jiao Tong University, Shanghai, China

- This paper presents an algorithm for multi-robot group to keep formation when they encounter the dynamic obstacles.
- An improved velocity potential field of dynamic obstacle is proposed.
- A method combining distributed control and consensus protocol is proposed.
- The robot formation can maintain the original formation as much as possible or autonomously decompose to sub-formations and regroup.
An Extended Complementary Filter (ECF) for Full-Body MARG Orientation Estimation

Sebastian O.H. Madgwick¹, Samuel Wilson², Ruth Turk³, Jane Burridge³, Christos Kapatos³ and Ravi Vaidyanathan⁴

¹x-io Technologies Ltd, Bristol, UK
²SERG Technologies Ltd, London, UK
³University of Southampton, Southampton, UK
⁴Imperial College London, London, UK

- The Extended Complementary Filter (ECF) is presented as a lightweight sensor fusion algorithm for orientation estimation.
- A compensation strategy for orientation estimation in magnetically polluted environments is proposed and demonstrated.
- Details of implementation in telehealth applications are provided.

Role of Operator Muscle Coactivation towards Intuitive Interaction with Haptic Assist Devices

Antonio Moualeu¹, Kevin Pluckter², Jun Ueda³

¹Georgia Institute of Technology
²Intuitive Surgical, Inc.
³Georgia Institute of Technology

- An operator’s muscle coactivation information is a necessary addition to standard control system inputs (e.g., kinetic information), in order to improve the control of haptic assist devices in industrial applications.
- Significant improvements in offline cross-validation accuracy and training time of an intent classifier were observed.

Assist-As-Needed Control of a Wearable Lightweight Knee Robotic Device

Kyle Hunte¹, Siyu Chen², Jingang Yi², Hao Su³

¹Department of Electrical & Computer Engineering, Rutgers University
²Department of Mechanical & Aerospace Engineering, Rutgers University
³Department of Mechanical Engineering, City University of New York

- A control approach for a wearable assistive knee exoskeleton actuated by quasi-direct drives (QDD).
- The QDD features include lightweight, high output torque and frequency response.
- A muscle synergy-based predictor is used to estimate the human torque that is applied to model predictive control.
- Human-in-the-loop simulation shows the QDD system assists and reduces the human torque required during walking.
**Session WeBT10**

Room T10

Wednesday, July 8, 2020, 13:30–14:45

**Planning and Navigation II**

Chair Hugh H.-T. LIU, University of Toronto
Co-Chair Di Deng, Carnegie Mellon University

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13:30–13:45 **WeBT10.1**

**Motion Planning for a Redundant Planar Snake Robot**

Omar Itani¹, Elie Shammas¹

¹Vision and Robotics Lab, American University of Beirut

- Introducing density functions, a geometric motion planning tool for planar floating four-link snake robots.
- Gaits belong to a well-defined sub-manifold in the base space which is defined by holonomic constraint.
- Gait generation tool is not as restrictive compared to prior methods in literature.

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14:00–14:15 **WeBT10.2**

**Guarding a Territory Against an Intelligent Intruder: Strategy Design and Experimental Verification**

Han Fu¹, Hugh H.-T. Liu¹

¹University of Toronto Institute for Aerospace Studies

- A near-optimal target defense strategy against an intelligent intruder,
- Handles a faster intruder and any convex target area, takes advantages of the non-zero capture range, easy to implement,
- Experiment proved effective. A barrier is found that the intruder is guaranteed to be captured if starts above.

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14:15–14:30 **WeBT10.3**

**Robotic Exploration of Unknown 2D Environment Using a Frontier-based Automatic-Differentiable Information Gain Measure**

Di Deng, Runlin Duan, Jiahong Liu, Kuangjie Sheng, and Kenji Shimada

Department of Mechanical Engineering, Carnegie Mellon University

- Introduce a boundaryness map to drive robots to uncertain and unexplored regions.
- Incorporate a differentiable fuzzy logic filter to convert discrete information gain to a continuous function.
- Optimize path length and information gain using gradient of viewpoints with automatic differentiation.

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14:30–14:45 **WeBT10.4**

**Development of Sensing System for Indoor Navigation of Visually Impaired Person with Inertial and Geomagnetic information**

Min Li, Jayanth Ammanabrolu

Department of Mech. and Civil Engineering

Minnesota State University Mankato

Mankato, MN 56001, USA

- Indoor location and orientation estimation
- Sensor fusion algorithm development
- Prototype development of the sensing system

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14:30–14:45 **WeBT10.5**

**Navigation of Autonomous Mobile Robots in Diverse Terrain**

Terrence P. Fries

Indiana University of Pennsylvania

- Autonomous navigation that adapts to diverse terrain
- Diverse terrain conditions represented using fuzzy linguistic variables
- Novel evolutionary encoding scheme that encodes both path and trajectory
- Real-time response to changes in a dynamic environment
Estimation and Filtering

Chair Shaohui Foong, Singapore University of Technology and Design
Co-Chair Agus Hasan, University of Southern Denmark

13:30–13:45 WeBT11.1

High Angular Rates Estimation using Numerical Phase-Locked Loop Method
Chee How Tan¹, Danial Suflyan bin Shaiful¹, Emmanuel Tang¹, Gim Song Soh¹ and Shaohui Foong¹
¹Engineering Product Development Pillar, Singapore University of Technology and Design, Singapore

- A PLL-based approach is formulated to estimate the high angular rate of a spinning samara-inspired UAV using onboard magnetometer measurements.
- A numerical simulation evaluated the rate estimation, up to twice the gyroscope sensing limit.
- The algorithm is experimentally tested on a benchtop setup and on a flying UAV with a low tracking rms error of 0.0674 Hz and 0.0479 Hz respectively.

13:45–14:00 WeBT11.2

eXogenous Kalman Filter for State Estimation in Autonomous Ball Balancing Robots
Agus Hasan
Center for Unmanned Aircraft Systems
University of Southern Denmark

- We present discrete-time eXogenous Kalman Filter (XKF) for state estimation in an autonomous Ballbot.
- The objective is to estimate the position and attitude using measurement from a low cost Inertial Measurement Unit (IMU).
- Experimental results show the proposed XKF algorithm provide better results than the EKF.

14:00–14:15 WeBT11.3

Adaptive Transfer Case Clutch Touchpoint Estimation with a Modified Friction Model
Wenpeng Wei¹, Hussein Dourra², Guoming G. Zhu¹
¹Mechanical Engineering, Michigan State University, East Lansing, MI
²Magna International, Troy, MI

- A model-based clutch touchpoint adaptive estimation algorithm is developed based on the clutch actuation system model;
- Modified General Kinetic Friction Model is used to describe nonlinear friction behavior accurately; and
- Experimental validation shows the advantage of the proposed model-based algorithm in accuracy and robustness.

14:15–14:30 WeBT11.4

Detecting Physiological Changes in Response to Sudden Events in Driving: A Nonlinear Dynamics Approach
Zhizhe Yu¹, Maolin Fan², Chun-Air Chou², Sheng-Chieh Yen¹, Yingyi Lin²
¹Biomedical Engineering, Rochester Institute of Technology, New York, USA
²Mechanical & Industrial Engineering, Northeastern University, Massachusetts, USA

- Our approach aims to capture the coupling dynamics between EEG and EMG in response to emergency braking events in driving tasks.
- Applying the computer vision algorithm to recurrence plots of EEG and EMG, our approach can detect braking intentions 300 ms in EEG and 194 ms in EMG prior to the actual emergency braking.

2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
Identification and Estimation in Mechatronics
Chair Kenn Oldham, University of Michigan
Co-Chair Julio Fajardo, Universidad Galileo

13:30–13:45 WeBT12.1

An Extremum Seeking Estimator Design and Its Application to Monitoring Unbalanced Mass Dynamics
Melih Cakmakci¹, Stefan Ristevski¹
¹Department of Mechanical Engineering, Bilkent University, Ankara, Turkey

• A non-linear observer design utilizing an extremum seeking algorithm was developed.
• Works for a certain class of error dynamics where the model uncertainty can be factored out from the rest of the non-linear function
• Demonstrated the utilization of the proposed estimator to an unbalanced mass for locomotion example

13:45–14:00 WeBT12.2

Drivetrain System Identification in a Multi-Task Learning Strategy using Partial Asynchronous Elastic Averaging Stochastic Gradient Descent
Tom Slaessens¹,², Guillaume Crevecour¹,²
¹EMSME, Ghent University, Belgium
²EEDT Decision & Control, Flanders Make

• An algorithm is proposed to extend the generalization capabilities of individual models within a fleet, without having access to the full dataset.
• The algorithm is applied to the joint system identification of a group of small wind turbine drivetrain simulators.
• Extended generalization capacities up to an order of magnitude are shown even to outside the fleet’s training data distribution.

14:00–14:15 WeBT12.3

A Robust H∞ Full-State Observer for Under-Tendon-Driven Prosthetic Hands
J. Fajardo¹, D. Cardona¹, G. Maldonado¹, A. Ribas², E. Rohmer²
¹FISICC, Galileo University, Guatemala City, Guatemala
²DCA, FEEC, UNICAMP, Campinas, São Paulo, Brazil

• Point 1. Estimation of angular displacement and velocity for under-tendon-driven machines.
• Point 2. Discrete-Time H∞ Full-State Observer Characterization.
• Point 3. Robust observer gain matrix obtained using Linear Matrix Inequalities machinery.

14:15–14:30 WeBT12.4

Estimating Perturbations to Laser Position on Tissue for Lissajous Scanning in Endomicroscopy
Joonyoung Yu¹, Mayur Birla¹, Miki Lee², Gaoming Li², Haijun Li², Thomas D. Wang², and Kenn R. Oldham¹
¹Mechanical Engineering, University of Michigan – Ann Arbor, USA
²Internal Medicine, University of Michigan – Ann Arbor, USA

• Presents an algorithm that can be used to estimate perturbations to position of the laser and reduce motion artifacts in single-pixel imaging applications.
• The algorithm uses EKF (Extended Kalman Filter) to estimate perturbations and reconstruct images.
• The results of applying the algorithm to images with both real and simulated motion artifacts are discussed.

14:30–14:45 WeBT12.5

Estimation of mobile robot’s center of gravity for rollover detection
Muhammad Hamad Zaheer¹, Se Young Yoon¹
¹University of New Hampshire

• Mobile robots are susceptible to rollover due to shift in center of gravity caused by load
• Least square estimation method is evaluated to determine the center of gravity of a loaded mobile robot
• Location of the center of gravity can be used to detect when the robot is in danger of rolling over
Development of a Low-friction Motor using Bearings as Gear Teeth

Masahiro Kawazawa¹, Sho Sakaino², and Toshiaki Tsuji¹
¹Salama University
²University of Tsukuba

- Compact gearboxes with high reduction ratio are needed.
- Reduced backdrivability due to amplified friction is the issue.
- A low-friction gearbox using bearings as gear teeth is proposed.
- Bearings were introduced only in the first stage.

Linear Negative Stiffness Honeycomb Actuator with Integrated Force Sensing

Temirlan Galimzhanov, Altay Zhakatayev, Ramil Kasparyan, Zhanat Kappassov and Huseyin Atakan Varol
Nazarbayev University, Nur-sultan City, Kazakhstan

- Negative stiffness honeycombs (NSHs) are parallel and series assembly of negative stiffness beams.
- In this work, we demonstrate the feasibility of the NSHs as nonlinear compliance elements in variable impedance actuated systems.
- Another novelty is the integration of magnetic sensing for force and compression estimation of the NSH structures.
- Experiments show high accuracy force and position tracking while varying system stiffness.

Suppression of Torque Ripple Caused by Misalignment of the Gearbox by using Harmonic Current Injection Method

Soo-Hwan Park, Jin-Cheol Park, Sung-Woo Hwang, Jae-Hyun Kim, Hyeon-Jin Park, and Myung-Seop Lim, member, IEEE
Department of Automotive Engineering, Hanyang University, Seoul 04763

- Problem to solve: Torque ripple caused by shaft misalignment in gearbox
- How to solve: Injecting harmonic currents to generate torque ripple which has same amplitude but opposite phase to the misalignment torque ripple into the motor
- Using this method, a high degree of torque control can be achieved with even a low quality gearbox.

Input modeling for active structural elements – extending the established FE-Workflow for modeling of adaptive structures

M. Böhm¹, S. Steffen¹, J. Gada¹, F. Geiger¹, W. Sobek¹, M. Bischoff¹, O. Sawodny¹
¹University of Stuttgart

- Adaptive structure can react to their surroundings, e.g. varying loads
- There are different actuation principles:
  - force and displacement actuation
  - Serial or parallel setup
- Rigorous modeling approach with mild assumptions on the structure
- Results illustrate feasibility of modeling approach and mass savings potential
Switching Controller-less Approach and Contact Controls Based on Force Impulse Regulator

Yusuke Kawai, Yuki Yokokura, Kiyoshi Ohishi, Toshimasa Miyazaki
Nagaoka University of Technology

Experimental results

Proposed approach and contact controls

Design of a Mechanical Tunable Resonant Fast Steering Mirror

Johannes Schlarp, Ernst Csencsics, Gabriel Doblinger and Georg Schitter
Automation and Control Institute, Vienna University of Technology, Austria

Experimental setup and results

Development of a Surgical Instrument with a Single Strain Area for Measuring Biaxial Cutting Forces

Masaya Suzuki¹, Satoko Abiko¹, Teppei Tsujita², Koyu Abe³
¹Shibaura Institute of Technology, Japan
²National Defense Academy of Japan
³Allsafe Japan LTD.

This paper proposes the development of a surgical instrument with a single strain area for measuring biaxial cutting forces.

An oval shape is designed in the strain area to obtain both bending and compression forces.

This paper carries out Tofu cutting experiments to demonstrate the validity of the developed instrument in a practical situation.

How to get a Parcel surfing

Fabian Westbrink¹, Andreas Schwung¹, Steven X. Ding¹
¹South Westphalia University of Applied Sciences, Soest, Germany
²University of Duisburg-Essen, 47057 Duisburg, Germany

Peristatic wave for parcel transport

Defining required wave height and speed

Wholesome DEM simulation to exchange manual tests

Tofu Cutting Experiment
### Achieving Efficient Controlled Flight with A Single Actuator

Luke Soe Thura Win, Shane Kyi Hia Win, Danial Sufiyan, Gim Song Soh and Shaohui Foong, Member, IEEE  
Engineering Product Development, Singapore University of Technology & Design, Singapore

- Conceptualization of a Monocopter with a single motor for both altitude and horizontal control using square cyclic control strategy.
- Use of Genetic Algorithm to find optimal motor location and 2D wing geometry for passive stability and optimal hover thrust.
- Indoor experiments verify the controllability of the system following a figure eight trajectory with minimal oscillation.

### A Central Pattern Generator-Based Control Strategy of a Nature-Inspired Unmanned Aerial Vehicle

Danial Sufiyan, Ying Hong Pheh, Luke Thura Soe Win, Shane Kyi Hia Win, Gim Song Soh and Shaohui Foong

- A control strategy based on a Central Pattern Generator (CPG) for a nature inspired aerial vehicle was formulated using a system of Kuramoto oscillators.
- Policy Gradients with Parameter-based Exploration was used to determine the oscillator parameters.
- The proposed control strategy was implemented on an actual prototype and subject to position control tests.

### Attitude-Constrained Time-Optimal Trajectory Planning for Rotorcrafts: Theory and Application to Visual Servoing

Xuetao Zhang1, Yongchun Fang1, Xuexiang Zhang1, Peiyao Shen1, Jingqi Jiang1, Xiang Chen1  
1Institute of Robotics and Automatic Information System, Tianjin Key Laboratory of Intelligent Robotics, Nankai University, Tianjin 300071, China  
2Department of Electrical and Computer Engineering, University of Windsor, Ontario, Canada

- Proposed algorithm:
  1. An $H_\infty$ minimum-time trajectory planning framework is proposed to generate real-time feasible minimum-time rotorcraft trajectories under velocity, thrust, roll and pitch angle constraints.
  2. It is the first time that the $H_\infty$ approach is successfully extended to the underactuated rotorcraft system subject to velocity constraints and non-convex input constraints.
  3. The well-known FOV constraints for visual servoing of rotorcrafts can be handled within this framework.

### Reinforcement Learning Control for Multi-axis Rotor Configuration UAV

Yi Wei Dai1, Chen Huan Pi1, Kai Chun Hu1, Stone Cheng1  
1National Chiao Tung University, Hsinchu, Taiwan

- Propose a multiusability reinforcement learning controller design method in low-level control of multi-axis rotor configuration unmanned aerial vehicle.
- Demonstrate the flight control of quadrotor and hexrotor using trained policy in simulator to present the stability on different multi-rotor, and compared the performance with the one previously introduced by trained quadrotor.

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**Fuzzy adaptive sliding mode control for unmanned quadrotor**

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**Paper Number:** 269  
**Author:** Xiaoyu Shi, Yuhua Cheng

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2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
Mobile Robots III
Chair Jongeun Choi, Yonsei University
Co-Chair Guoliang Liu, Shandong University

11:00–11:15 ThAT4.1

Prediction of Reward Functions for Deep Reinforcement Learning via Gaussian Process Regression
Jaehyun Lim¹, Seungchul Ha¹, Jongeun Choi¹
¹School of mechanical engineering, Yonsei Univ., Seoul, South Korea

An efficient way to solve the inverse reinforcement learning problem based on the Gaussian process regression with $l_1$-regularization is proposed.
The experimental results clearly show that the robots can clone the human's optimality in obstacle avoidance navigation tasks using only with a very small number of human demonstration datasets.

11:15–11:30 ThAT4.2

Online Collision Avoidance for Human-Robot Collaborative Interaction Concerning Safety and Efficiency
Guoliang-Liu_1¹, Haoyang-He_2¹, Guohui-Tian_3¹, Jianhua-Zhang_4², Ze-Ji_5³
¹Shandong University
²Hebei University of Technology
³Cardiff University

A novel real-time collision avoidance approach for manipulator considering the motion status of the human.
A motion sampling mechanism for motion planning to avoid local minimum.
Safety and efficiency are considered during avoidance.

11:30–11:45 ThAT4.3

Modular ROS Based Autonomous Mobile Industrial Robot System for Automated Intelligent Manufacturing Applications
Ren C. Luo, Shang Lun Lee, Yu Cheng Wen, Chin Hao Hsu
Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan

We propose a finite state machine based method to integrate and manage various modular functions on the robot which makes it have a great talent on mobility and manipulation.
In the experiments, an industrial scenario has successfully demonstrated.

11:45–12:00 ThAT4.4

Control-oriented Modeling of Soft Robotic Swimmer with Koopman Operators
Maria L. Castaño¹, Andrew Hess, Giorgos Mamakoukas, Tong Gao, Todd Murphy and Xiaobo Tan¹
¹Department of Electrical and Computer Engineering, Michigan State University, United States of America

A data-driven approach that utilizes Koopman operators to obtain linear, control-oriented models for soft robotic swimmers is proposed.
Two different methods for constructing the derivatives-based basis functions for the Koopman operators are presented.
Specifically, one method utilizes higher-order derivatives of the measured states (HOD), which are estimated using high-gain observers, and the other utilizes the assumption that the dynamics structure of the soft robotic swimmer somewhat resembles that of a rigid, tail-actuated robotic fish (RFI).
The proposed Koopman schemes are trained and then validated using data obtained from high-fidelity CFD simulations. Validation results show that both methods are promising, but the one based on estimated derivatives demonstrates higher accuracy in predicting the robot's behavior.
A suction end effector with multiple pneumatically driven joints composed of flat tubes and link mechanisms

Junya Tanaka¹ and Nobuto Matsuhira²
¹Toshiba Corporation
²Shibaura Institute of Technology

• We developed a suction end effector with five pneumatically driven joint units connected in series.
• The end effector allows more items to be held by both suction and grasping.
• The pneumatic drive structure is characterized by sandwiching a rigid link member by a flat tube to achieve both drivability and load resistance.

MISO Model Free Adaptive Control of Single Joint Rehabilitation Robot Driven by Pneumatic Artificial Muscles

Yi Li¹, Quan Liu², Wei Meng⁴,⁵, Yunlong Xie⁶, Qingsong Ai⁷, Sheng Q Xie⁸
¹School of Mechanical Science and Engineering, Huazhong University of Science and Technology, Wuhan, China
²School of Information Engineering, Wuhan University of Technology, 122 Luoshi Road, Wuhan, China
³School of Electrical and Electronic Engineering, University of Leeds, LS2 9JT, UK

• MISO-IMFAC is proposed for the rehabilitation robot driven by antagonistic PAMs.
• Adding a term representing error change to the original control input criterion function.
• The control algorithm can improve the accuracy of angle trajectory tracking and ensure the stable performance.

Self-sensing of Dielectric Tubular Actuator and Its Validation in Feedback Control

Shengbin Wang, Theophilus Kaaya, Zheng Chen*
Department of Mechanical Engineering, University of Houston, 4800 Calhoun Rd, Houston, TX 77004, USA.

• The paper deals with the application of self-sensing techniques for measurement and closed-loop position control of a particular class of dielectric elastomer (DE) actuators (tubular DE actuator)
• The proposed self-sensing methodology relies on a static experimental map of the actuator stroke vs its capacitance, capacitance measurements are performed by superposing a high-frequency sensing signal on the actuation signal, and resolving the associated current and voltage via the FFT.
### Tele-operation

**Chair:** Shafiqul Islam, Xavier University of Louisiana  
**Co-Chair:** Nobuto Matsuhiara, Shibaura Institute of Technology

#### 11:00–11:15 ThAT6.1

**Multilateral Haptic Feedback Control by Transmission of Force Information**  
Yuki Nagatsu1, and Hideki Hashimoto1  
1Department of Electrical Electronic, and Communication Engineering, Chuo University, Japan

- Haptic feedback will be important for teleoperation and remote communication.  
- Multilateral control has been studied as an extension of bilateral haptic feedback control.  
- This paper proposes multilateral haptic feedback only by force transmission without position information transmission.

#### 11:30–11:45 ThAT6.3

**Flexible Remote-Controlled Robot System with Multiple Sensor Clients Using a Common Network Communication Protocol**  
Satoru Miki1, Takuya Nishioka1, Hyuga Sekiya1, and Nobuto Matsuhiara1  
1Shibaura Institute of Technology

- We developed a flexible remote-controlled robot system. Robot elements are flexibly combined into the system as clients using RSNP.  
- We verified the system with a mobile robot and multiple sensors (LRF, ultrasonic sensor, and illuminance sensor) and confirmed the effectiveness by experiments.  
- Additionally, we conducted a remote control of the mobile robot at a 300 km distance. Next, the system will be used in more complicated environments.

#### 11:45–12:00 ThAT6.4

**Adaptive robust control of bilateral teleoperation systems for synchronization in time**  
Yanbin Liu1, Weichao Sun2, Zheng Chen2  
1National Defense Academy, Japan  
2Shibaura Institute of Technology

- Expect for the stability and transparency, synchronization in time is also considered for bilateral teleoperation.  
- Reference generator is designed on slave side to predict the states of the master system.  
- Adaptive robust control method is employed to deal with the uncertainties of the both master and slave systems.

#### 12:00–12:15 ThAT6.5

**Velocity/Position Based Robust Control for Shared Autonomous System Over Open Communication Networks-Experimental Results**  
Shafiqul Islam  
Xavier University of Louisiana, 1 Drexel Drive, LA 70125.

- Develop shared control algorithms by using both delayed position and position-velocity.  
- Employed robust adaptation learning laws locally with to estimate the interaction properties between human and master and between slave and remote environment  
- Experimentally compares both position-velocity/position and interaction reflection based algorithm over open internet networks with the presence of delay and uncertainty
Robotic Manipulators III
Chair Zheng Chen, Zhejiang University
Co-Chair Zike Lei, University of Windsor

11:00–11:15  ThAT7.1

Robot Hand Interaction Using Plastic Deformation Control with Inner Position Loop
Kenichi Murakami1, Koki Ishimoto2, Taku Senoo3, Masatoshi Ishikawa4
1Information Technology Center, The University of Tokyo
2Graduate School of Information Science and Technology, The University of Tokyo
3Graduate School of Advanced Science and Engineering, Hiroshima University

• Proposing a robust control law for modeling and parameter errors by realizing plastic deformation control with an actual robot hand system
• Introducing Inner position loop into the plastic deformation control
• Succeeded absorbing force from human finger

11:15–11:30  ThAT7.2

An Efficient Inverse Kinematics Algorithm for Continuum Robot with a Translational Base
Jia Li, Peiqiu Wu, Zhong Li, Dafang Meng, and Yuanqian Lei

Objective: This paper aims to solve the inverse kinematics for continuum robot with a translation base.

Method: Based on the constant curvature assumption and the geometric analysis method, the forward kinematic model of the continuum robot is established. By analyzing the features of the parameters of the robot’s workspace, the geometric is replaced section by section using the egg curve. The egg curve is determined according to the design parameters of the continuum robot initially, and then it is updated iteratively based on the end position of the continuum robot.

Results: Simulation results verify the algorithm is effective with an extremely quick convergence speed and a very high computational efficiency. Moreover, at the neighborhood of the singular points, the speed of convergence is not affected. Experiment results show the positioning errors relative to the effective total length of the manipulator are satisfactory. The average distance error is less than 1.79%, and most of the distance errors are no more than 2.5%.

Conclusion: The inverse kinematics algorithm proposed in this paper can be well-used in the real-time control of the continuum robot with a translation base. Moreover, the algorithm is generic, which can be extended for analyzing such continuum robots.

Keywords: Inverse kinematics, wire-driven, continuum manipulator, egg curve

11:30–11:45  ThAT7.3

RBF-Neural-Network-Based Adaptive Robust Control for Nonlinear Bilateral Teleoperation Manipulators With Uncertainty and Time Delay
Zheng Chen1, Fanghao Huang1, Wei-Chao Sun2, Jason Gu3, Bin Yao4
1Zhejiang University, Hangzhou, China
2Harbin Institute of Technology, Harbin, China
3Dalhousie University, Halifax, Canada
4Purdue University, West Lafayette, USA

• RBF-neural-network-based adaptive robust control is proposed for teleoperation manipulators to cope with delays, nonlinearities and uncertainties.
• The environment dynamics is modeled in a general form with RBF neural network
• The stability and good transparency are achieved simultaneously.

11:45–12:00  ThAT7.4

HILS Using a Minimum Number of Joint Module Testbeds for Analyzing a Multi-DoF Manipulator
Yusuke Noda1, Teppei Tsujita2, Satoko Abiko3, Teppei Tsujita2, Satoko Abiko3, Daisuke Sato4, Dragomir N. Nenchev5
1Department of Mechanical Systems Engineering, Tokyo City University
2Department of Mechanical Engineering, National Defense Academy of Japan
3Department of Electrical Engineering, Shibaura Institute of Technology

• Using a Hardware-in-the-Loop Simulator (HILS) is one of the solutions of robot motion analysis
• HILS requires number of joint testbeds as many as robot joints
• This paper proposes TIM (Time Increment Method) and JSM (Joint Switch Method) that can analyze multi-DoF robot motion with minimum number of joint testbeds

12:00–12:15  ThAT7.5

Infinite Torsional Motion Generation of a Spherical Parallel Manipulator with Coaxial Input Axes
Illyas Tursynbekov1, Almas Shintemirov1
1Department of Robotics and Mechatronics, Nazarbayev University

• A novel approach for infinite torsional motion generation of a Spherical Parallel Manipulator with Coaxial Input Axes.
• Generation of input joint trajectories within the precomputed space of feasible configurations.
• Numerical case study using simulation model of the manipulator revealing periodic nature and similarities between the input joint velocities.

2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)
Motion Control

Chair Hideki Hashimoto, Chuo University
Co-Chair Yuanlong Xie, Huazhong University of Science and Technology

Sliding-mode Control with Multi-sensor Fusion for Orientation of Spherical Motion Platform
Seong-Min Lee, Student Member, IEEE
1 Mechanical, Aerospace, and Nuclear Engineering, Ultras National Institute of Science and Technology, South Korea

- This research presents control system design for multi-DOF spherical motion platform.
- For orientation measurement, sensor fusion of both an optical sensor and IMU is utilized to control the cockpit rotation.
- The experimental results show the sensing and control operation are successfully implemented using the real scale SMP.

Study on Self-Position Estimation and Control of Active Caster Type Omnidirectional Cart with Automatic / Manual Driving Modes
Kenji Miyashita, Masayoshi Wada
Tokyo University of Agriculture and Technology

- Point 1. We developed an active caster type omnidirectional cart equipped with direct manual control.
- Point 2. This cart enables direct push-pull operation by disconnecting the motor power to the active caster by the electromagnetic clutches.
- Point 3. We developed and evaluated systems for self-position estimation, path recording, and path following of this cart.

Iterative Super-Twisting Sliding Mode Control: A Case Study on Tray Indexing
Wenxin Wang1,2, Jun Ma2,3, Xiaocong Li4, Haiyue Zhu4, Chek Sing Teo1,4, Tong Heng Lee2
1 SIMTech–NUS Joint Lab on Precision Motion Systems
2 Department of Electrical and Computer Engineering, National University of Singapore
3 Department of Mechanical Engineering, University of California, Berkeley
4 Mechatronics Group, Singapore Institute of Manufacturing Technology

- Totally model-free method
- Chattering suppression
- Robustness
- Fast convergence
- Applicable to other systems

The 2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics

Coupled Sliding Mode Control of an Omnidirectional Mobile Robot with Variable Modes
Yuanlong Xie, Xiaolong Zhang, Wei Meng, Shane Xie, Liquan Jiang, Jie Meng, and Shuting Wang

- A new coupled sliding surface vector is presented to guarantee that the tracking error converges to zero.
- Novel modified reaching laws are proposed to eliminate the chattering phenomenon.
- With a two-stage fuzzy logic system, the robot achieves the optimal autonomous switched control.
- Under complex conditions, the experiments verify the effectiveness and practicability of this method.

A Two-Wheeled Type Vehicle to Carry Luggage in Cooperation with Human
Hironori Matsubara1, Yuki Nagatsu1, Hideki Hashimoto1
1 Department of Electrical Electronic and Communication Engineering, Chuo University, Tokyo, Japan

- Point 1. The purpose of research is the realization of an assisting vehicle using an inverted two-wheeled vehicle.
- Point 2. Inverted two-wheeled vehicles have the advantages of high mobility, such as small size, cost, and the ability to turn on the spot.
- Point 3. The proposed control method is derived theoretically and its effectiveness is confirmed by experiments.
Noncontact capacitive sensing + IMU sensors.

Compared with purely using inertial sensors, the sensor fusion method reduced more than 100-ms latency on average.

The soft robotic glove includes inverse kinematics and forward kinematics are demonstrated in detail.

The proposed robotic lumbar brace may have potentials in scoliosis rehabilitation.

A soft robotic glove uses positive-negative pneumatic actuator made of bellows, which weighs only 148g and has 6 DOFs.

A matching portable pneumatic box with six outputting gas paths can achieve assisted training and impedance training by adjusting pressure and flow.

A Novel Soft Robotic Glove with Positive-negative Pneumatic Actuator for Hand Rehabilitation

Non-Periodic Lower-Limb Motion Recognition with Noncontact Capacitive Sensing

The State Key Laboratory of Fluid Power and Mechatronic Systems, School of Mechanical Engineering, Zhejiang University, 31002

Human-centered Robotics

Chair Jiajie Guo, Huazhong University of Science and Technology
Co-Chair Siyu Chen, Rutgers University

Human-centered Robotics

Chair Jiajie Guo, Huazhong University of Science and Technology
Co-Chair Siyu Chen, Rutgers University
An Experimental Analysis of Pipe Inspection using Solar Panel Receiver for Visible Light Communication and Energy Harvesting

Wen Zhao\(^1\), Mitsuhiro Kamezaki\(^1\), Kaoru Yamaguchi\(^1\), Minoru Konno\(^2\), Akihiko Onuki\(^2\), Shigeki Sugano\(^1\)
\(^1\)Waseda University
\(^2\)Tokyo Gas Co., Ltd.

- Analysis of the performance of the solar panel receiver for VLC and energy harvesting (EH).
- The hybrid transmission method could increase the receiving current of solar panel with less influence on the VLC quality.

Bolt loosening detection using multi-purpose robot hand

Fumiya Shimada\(^1\), Kenichi Murakami\(^1\), Taku Senoo \(^1\), Masatoshi Ishikawa\(^1\)
\(^1\)The University of Tokyo

- We detected loosening of bolts by the tactile information obtained by vibrating the object with multi-purpose robot hand.
- We modeled the relationship of the rattling size and the force the fingertip is subjected to.
- We successfully detected bolt loosening for three types of objects.

Comprehensive Performance Evaluation of Large Span Metal Roof Based on AHP-FCE

Xueyao Yang\(^1\), Limian Yang\(^1\), Yunhua Li\(^1\), Lianming Su\(^1\)
\(^1\)School of Automation Science and Electrical Engineering
Beihang University, Beijing, China

- This paper analyzed the causes of metal roof failure and established a real-time metal roof health monitoring system.
- A health evaluation method of metal roof was proposed based on analytic hierarchy process and fuzzy comprehensive evaluation, which was initially applied to the actual roof health monitoring system.

Extension of the Capture Range Under High-Speed Motion Using Galvanometer

Yuriko Ezaki\(^1\), Yushi Moko\(^1\), Haruka Ikeda\(^1\), Tomohiko Hayakawa\(^1\) and Masatoshi Ishikawa\(^1\)
\(^1\)Graduate School of Information Science and Technology, University of Tokyo

- Doubling capture range for inspecting tunnels under high-speed motion controlling a galvanometer mirror.
- Suppressing resonance noise of the mirror from the view of Fourier analysis.
- Restraining the fluctuation of the mirror during an exposure period less than 1.8% of the switching angle and recognizing a line of 1 mm width in captured images placed 2 m away from the camera.

Magnetic Machine Perception for Reconstruction of Non-uniform Electrical Conductivity based on Eddy Current Model

Bingjie Hao\(^1,2\), Kok-Meng Lee\(^2\), Ivy Chang\(^2\)
\(^1\)State Key Lab. of Dig. Manuf. and Equip. Tech., Huazhong U. of Sci. and Tech., China
\(^2\)George W. Woodruff Sch. of Mech. Eng., Georgia Institute of Technology, USA

- Present a machine perception method for reconstructing eddy current (EC) induced in an electrical conductor and its non-uniform conductivity.
- Numerically verified with data simulated using finite element method, along with a parametric study for design optimization.
- Experimentally validated demonstrating detection of abnormal conductivity and measurement of non-uniform thickness equivalent to conductivity anomaly.
Study of Current Emotion and Muscle Fatigue Evaluation Method for a Walking Assistive Device
Jun Yan Yang¹, Jyun Rong Zhuang¹, Guan Yu Wu¹, and Eiichiro Tanaka¹ Member, IEEE
¹Graduate School of Information, Production and Systems, Waseda University.
2-7 Hibikino, Wakamatsu-ku, Kita-Kyushu, Fukuoka 808-0135, Japan

- Muscle fatigue evaluation method based on NIRS.
- Real-time 3D human condition model of emotion and fatigue from EEG, HRV and NIRS
- Promote the control strategy of the walking assistive device.

Online Estimation of Continuous Gait Phase for Robotic Transtibial Prostheses Based on Adaptive Oscillators
Dongfang Xu¹, Simona Crea², Nicola Vitiello², and Qining Wang¹
1. College of Engineering, Peking University, China
2. The BioRobotics Institute, Scuola Superiore Sant’Anna, Italy

- This study focuses on the online estimation of continuous gait phase based on robotic transtibial prosthesis signals.
- First, we adopt the prosthetic foot deformation information to detect the heel strike as the start timing (reset 0 rad) of one gait cycle. Then we conduct the gait phase estimation based on adaptive oscillators using the prosthetic shank angle signal as input.

Design and Compliance Control of Rehabilitation Exoskeleton for Elbow Joint Anchylloses
Sihan Zhang¹, Qiuguo Zhu², Jun Wu³, Rong Xiong², Yong Gu²
¹Institute of Intelligent System and Control, Zhejiang University, Hangzhou, China
²College of Engineering, Peking University, China

- Frist, structural design of the rehabilitation exoskeleton was accomplished based on several simulations.
- Then, a torque controller and a compliance controller were designed to meet the requirements of control and treatment.
- Finally, Successful implementation of the controller in a rehabilitation exoskeleton robot verified the feasibility and realizability of the device.

On the Design of Rigid-Soft Hybrid Exoskeleton Based on Remote Cable Actuator for Gait Rehabilitation
Zhihao Zhou, Zilu Wang, and Qining Wang
College of Engineering, Peking University, China

- In this paper, we proposed a kind of rigid-soft hybrid structure, which not only meet the “soft” requirements without joint restriction, but also provide support for the limbs to implement the “rigid” function.
- The hybrid exoskeleton is based on no-joint design and assist human limbs by linear cable-driven actuator, which is driven by motor through cable-sheath transmission structure.
Effect of penetration force on drilling efficiency for seabed drilling robot

W. Toyama1, K. Isaka1, K. Tsumura1, T. Watanabe1, M. Okui1, H. Yoshida2 and T. Nakamura1
1Graduate School of Science and Engineering, Chuo University, Japan
2Marine Technology and Engineering Center, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan

- Point 1. Controlling the rotation speed and penetration force would enable an efficient excavation according to the ground characteristics.
- Point 2. The effects of different ground characteristics on excavation efficiency.
- Point 3. The effect of penetration force on excavation efficiency.

Analysis and Validation of a New Hydraulic Cylinder Nominal Dynamics

Satoru Sakai
Shinshu University

- A new Pressure Dynamics
- No linearization + No singular perturbation
- Analysis, Validation and Justification by Dirac Structure

A Normal Force Estimation Model for a Robotic Belt-grinding System

Yu-Hsun Wang1, Yuan-Chieh Lo2, and Pei-Chun Lin1
1Department of Mechanical Engineering, National Taiwan University, Taiwan
2Mechanical and Mechatronics System Research Laboratories, Industrial Technology Research Institute, Taiwan

- A force-sensorless normal force estimation model for a robotic belt grinding system with a free strand of abrasive belt was developed.
- A 3D model was constructed using integrated 2D interaction forces between the workpiece and the abrasive belt.
- The results confirm that the model can successfully predict a force profile, achieving force-sensorless conditions for a robotic grinding system.

Modeling and analysis of a hysteretic deformable mirror with electrically coupled actuators

A.E.M. Schmerbauch1, A.I. Vakis2, R. Huisman1, and B. Jayawardhana1
1,2ENTEG (DTPA1,CMME2), University of Groningen, The Netherlands
3Netherlands Institute for Space Research, Groningen, The Netherlands

- Presentation of the hysteretic deformable mirror concept
- Analysis of the electrical coupling behavior between the actuators
- Approach for inclusion of the electrical actuator coupling in the surface fitting process of the mirror

Figure: Electrical coupling between the actuators.
A Bidirectional Alignment Control Approach for Planar LED-based Free-Space Optical Communication Systems

Pratap Bhanu Solanki, Shaunak D. Bopardikar, Xiaobo Tan
Michigan State University

- Achievement of Line-of-Sight (LOS) in a planar setting between two transceivers.
- The problem is formulated as a dynamic system where:
  - Each agent maximizes its own measurement.
  - There is no communication between agents.
  - The moves are made in parallel.
- A novel control algorithm is implemented.
- Simulation results show the superiority of the approach over extremum seeking (ES) algorithm.

Adaptive Tracking Control of One-Dimensional Respiration Induced Moving Targets by Real-Time Magnetic Resonance Imaging Feedback

Yu-Hsiu Lee1, Xinzhou Li2, James Simonelli1, David Lu2, Holden H. Wu2, and Tsu-Chin Tsao1
1Department of Mechanical and Aerospace Engineering, UCLA, USA
2Department of Radiological Sciences, UCLA, USA

- Real-time MRI for instrument motion guidance under respiratory target motion.
- Adaptive tracking control to mitigate phase error.
- Experimentally demonstrate motion tracking in closed-bore scanner with 1-DOF hydrostatic platform.

An efficient control transition scheme between stabilization and tracking task of a MAGLEV platform enabling active vibration compensation

Daniel Wertjanz, Ernst Csencsics and Georg Schitter
Automation and Control Institute (ACIN), Technische Universität Wien, Austria

- Orientation independent system performance by design
- 2 sensor systems for 2 operational modes:
  - Stabilization in 6 DoFs
  - Tracking control in 3 out-of-plane DoFs
- Minimum jerk transition based on cross-fading error gain and a single PID controller
- Transition times ~50ms
- In-plane stabilization error <137nm rms

Motion Control of hydraulic actuators in presence of discrete pressure rail switching

Arpan Chatterjee1, Perry Y. Li1
1Department of Mechanical Engineering, University of Minnesota

- Novel Hybrid Hydraulic-Electric Architecture (HHEA) combines hydraulic and electric actuations to reduce energy consumption by 50-60% using a set of common pressure rails.
- A nominal backstepping controller is used in between pressure rail switches but it cannot handle discrete pressure rail switching with torque limited electrical components.
- Transition controller has been designed based on least-norm control to improve control performance during pressure rail transition events.
Hector SLAM with ICP Trajectory Matching

Weichen WEI1, Bijan Shirinzadeh2, Mohammadali Ghafarian3, Shunmugasundar Esakkiappan4 and Tianyao Shen5
12Monash University Australia

- Sensor fusion in SLAM cannot correct accumulated mapping errors.
- Estimating a robotic system posture in two separate frames provides a reference trajectory to examine mapping results.
- Compare two trajectories using ICP can find the transform matrix to correct mapping results.

A Partial Sparsification Scheme for Visual-Inertial Odometry

Zhikai Zhu1,2, Wei Wang1,2
1Institute of Automation, Chinese Academy of Sciences
2School of Artificial Intelligence, University of Chinese Academy of Sciences

- We propose a partial sparsification scheme for the marginalization of sliding window visual inertial odometry systems.
- We test our proposed scheme on public datasets to prove its effectiveness.
- We perform a run-time analysis of our proposed method to demonstrate that it is applicable to real-time operations.

Visual-inertial odometry system with simultaneous extrinsic parameters optimization

Xitian Gao, Baoquan Li, Wuxi Shi, Fanlei Yan
Tiangong University

- Optimize extrinsic parameters between the camera and IMU.
- Gyroscope bias, metric scale, and gravity vector are estimated by visual-inertial information.
- The velocity of each frame is calculated via previous state estimation directly.

Camera Intrinsic Parameters Estimation by Visual Inertial Odometry for a Mobile Phone with Application to Assisted Navigation

Lingqiu Jin, He Zhang, Cang Ye
Dept. of Computer Science, Virginia Commonwealth University

- Smartphone’s OIS causes camera intrinsic parameter (CIP) to change with its motion.
- Varying CIP is estimated from accelerometer data by using a linear model and refined by factor graph optimization.
- The proposed VIO w/ CIP estimation improves pose estimation accuracy.
- The VIO is validated by experiments with a robotic navigation aid.
Model-Based Robot Learning Control with Uncertainty Directed Exploration
Jujie Cao, Yong Liu, Jian Yang and Zaisheng Pan
1China Research and Development Academy of Machinery Equipment, China
2Zhejiang University, China

- Model Predictive Control with Posterior Sampling (PSMPC): to make the robot learn to control efficiently.
- Does approximate sampling from the posterior of the dynamic model.
- Applies model predictive control to achieve trajectory value uncertainty directed exploration.
- PSMPC guided policy optimization: to reduce the computational complexity of the resulting controller.

Amphibious Robot’s Trajectory Tracking with DNN-Based Nonlinear Model Predictive Control
Yaqi Wu, Anxing Xiao, Haoyao Chen
1Harbin Institute of Technology, Shenzhen, China
2Department of Mechanical and Energy Engineering, Southern University of Science and Technology, China
3Chinese University of Hong Kong, Hong Kong, China

- Design a deep neural network (DNN) as a precise black-box kinematic model of the amphibious robot.
- Design a DNN based nonlinear model predictive controller (DNN-N MPC) for the amphibious robot’s trajectory tracking task.
- Build a Gazebo based simulation platform and carry out several comparative simulations.

Compliant Motion Adaptation with Dynamical System during Robot-Environment Interaction
Haohui Huang, Haokun Wang, Xiaobo Liu, Linhan Yang and Chaoyang Song
1Department of Mechanical and Energy Engineering, Southern University of Science and Technology, China
2University of Science and Technology of China, China
3Chinese University of Hong Kong, Hong Kong, China

- A Compliant robot-environment interaction method is proposed based on closed-loop dynamic system.
- An adaptive interaction motion is generated through the proposed method which only depends on the contacting force instead of the impedance model.
- The compliant interaction behavior is achieved at the motion level which is more convenience for designing a position-based motion controller.
Micro and nano manipulation

Chair Ebubekir Avci, Massey University
Co-Chair Quang Minh Ta, Nanyang Technological University

13:30–13:45 ThBT6.1

Design of Optical Micromachines for Use in Biologically Relevant Environments

Philippa-Kate Andrew¹, Daniel Fan², Allan Raudsepp¹, Matthew Lofroth¹, Urs Stauffer¹, Martin A. K. Williams¹, Ebubekir Avci¹
¹Massey University, New Zealand
²Technische Universität Delft, the Netherlands

- Micromachines need to function in biologically relevant environments and adhesion between components is a key challenge to be overcome.
- The presence of tapered supports, and reduction of lever arm contact with the centre pin led to improved functionality in tris-buffered saline.
- Optical manipulation of the proposed lever mechanism is demonstrated in a biologically relevant environment.

14:00–14:15 ThBT6.3

Feedback-cascaded inverse feedforward for viscoelastic creep, hysteresis and cross-coupling compensation in dielectric-elastomer actuated XY stages

Jiang Zou¹, Peinan Yan¹, Ningyuan Ding¹, Guoying Gu*¹
¹Shanghai Jiao Tong University, Shanghai, China. (guguoying@sjtu.edu.cn)

- A DEA-XY stage is developed with a workspace of 2mm*2mm;
- PID controllers are adopted to remove both cross-coupling effect and creep nonlinearity;
- Direct inverse hysteresis compensators (DIHC) is employed to remove the rate-dependent hysteresis;
- Complex trajectories tacking control is achieved with the two-level controllers.

14:30–14:45 ThBT6.5

Electrophoresis-Based Adaptive Tube Model Predictive Control of Micro- and Nanoparticles Motion in Fluid Suspension

Juan Wu¹, Kaiyan Yu¹
¹Mechanical Engineering, The State University of New York at Binghampton

- Robust, simultaneous, and independent manipulation of multiple particles under coupled electric field.
- Online estimation for system unknowns.
- Analysis of manipulation capability and disturbance rejection for the system.
- Evaluation the relative position and maximum number of the particles.
- Validation of the proposed control scheme by experimental results.

14:15–14:30 ThBT6.4

FPGA-Based Characterization and Q-Control of an Active AFM Cantilever

Orod Kaveh, M. Bulut Coskun, Mohammad Mahdavi, and S. O. Reza Moheimani
The University of Texas at Dallas

- Active AFM probe with self-actuation/sensing capability
- FPGA-based implementation of feedthrough cancellation and Q-control systems
- Achieving a faster response time after reducing Q-factor from 268 to 81.7.

13:45–14:00 ThBT6.2

Multi-agent Control for Stochastic Optical Manipulation Systems

Quang Minh Ta and Chien Chern Cheah
Nanyang Technological University, Singapore

- This paper proposes a multi-agent robot control approach for coordinated manipulation of multiple micro-objects with Brownian perturbations.
- Several micro-hands are constructed by coordination of optically trapped micro-particles so as to grasp target micro-objects
- Coordinative control of the micro-hands is then performed to achieve cooperative manipulation of the micro-objects.
Optimized Mobile Robot Positioning for better Utilization of the Workspace of an attached Manipulator
Marc Forstenhäusler¹, Tim Werner¹, Klaus Dietmayer¹
¹Ulm University

- Goal: Get an optimized robot base placement to reach a set of given target points
- New modeling of the KUKA iiwa workspace, by splitting it into several tori
- Formulation of geometrical optimization problem, to calculate suitable base positions depending on the base position

Electrophoresis-Based Adaptive Manipulation of Nanowires in Fluid Suspension
Juan Wu¹, Xilin Li¹, Kaiyan Yu¹
¹Mechanical Engineering, State University of New York at Binghamton

- An adaptive control law designed for precise trajectory tracking of nanowires with input limitation.
- Online estimation of system unknowns.
- An efficient anytime motion planner with quick convergence and high efficiency.
- Preliminary validation for motion planners and control scheme by simulations.
- Integration of motion planning and adaptive control in real-time experiments.

Metrics and Methods for Evaluating Learning Outcomes and Learner Interactions in Robotics-Enabled STEM Education
S. M. M. Rahman
University of West Florida

- Robotics-enabled STEM education was investigated
- Metrics and methods for evaluating learning outcomes were proposed
- Metrics and methods for evaluating learner interactions were proposed
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