Tutorial at World Congress 2019, Krakow, Poland

Mechanism Design for Robots and Assistive Devices

Organized by TC for Linkage and Mechanical Control, and TC for Robotics and Mechatronics

Date: Sunday 2019/06/30
Place: Conference venue

Program:

09.00-09:05	Opening
09:05-09:50	“Case studies on mechanism design for mobile robots, electric wheelchairs, agricultural UGV and robot gripper“, Prof. Giuseppe Quaglia (Politécnico di Torino, Italy)
09:55-10:40	“Development of a walking assistive device for paralytic by collaborating medical-engineering and academic-industry“, Prof. Eiichirou Tanaka (Waseda University, Japan)
10:45-11:30	“Design, modeling and analysis of mechanism for assistive exoskeletons”, Prof. Shaoping Bai (Aalgorg University, Denmark)
11:30-11:45	Coffee break
11:45-12:30	“Development of tailor-made robots and mechanisms with complex joints”, Prof. Mathias Huesing (RWTH Aachen University, Germany)
12:35-13:20	“Solutions on assistive robotics at CESTER-LARM”, Prof. Giuseppe Carbone (University of Calabria, Italy) and Prof. Doina Pisla (Techincal University of Cluj-Napoca, Romania)
13:20-13:30	Closing

Organizers:

Prof. Victor Petuya, Chairman of TC for Linkage and Mechanical Controls (University of the Basque Country, Spain)
Prof. Yukio Takeda, Chairman of TC for Robotics and Mechatronics (Tokyo Institute of Technology, Japan)

Abstracts:

Title: Case studies on mechanism design for mobile robots, electric wheelchairs, agricultural UGV and robot gripper

Lecturer: Prof. Giuseppe Quaglia, Politécnico di Torino, Italy

Abstract

The tutorial will give an overview of mechanism design methodologies and solutions, applied to four different case studies:
- The epi.q mobile robot Family, addressed to surveillance and monitoring of indoor and outdoor environment, able to overcome small obstacles thanks to a specific locomotion system and epicycloidal gearing transmission;
- The wheelchair.q project: an electrical wheelchair able to move in closed and open space, on stairs, ramp and sidewalk;

- the agri.q mobile robot project, addressed to the develop of a mobile robot for agriculture application and usable as landing platform for drones;
- the QuBu gripper, developed for grasping object of different size and weight, having Hig accuracy and self-adaption, for manipulation task in industrial applications

Development of a walking assistance device for paralytic by collaborating medical-engineering and academic-industry.

Biography

Title Development of a walking assistive device for paralytic by collaborating medical-engineering and academic-industry

Lecturer Prof. Eiichiro Tanaka, Graduate School of Information, Production and Systems, Faculty of Science and Engineering, Waseda University, Japan

Abstract

There are so many over 1 million paralytic patients in Japan. Most of them have some features of walking; extending the toe of the foot and circumductive foot, etc. and it is dangerous because it is easy to stumble with a slight step. They have to train to improve and recover their gait, however, most of conventional assistive devices were attached some motors and very bulky. On the other hand, we developed a wearable and compact walking assistive device RE-Gait® for paralytic by collaborating medical-engineering and academic-industry as a practical product. We discussed and visited hospitals and care homes so many times, then we could find innovative idea; by utilizing the muscle structure and physiological phenomenon of the human, RE-Gait® can induce raising the foot only assisting the ankle joint motion. This device is very compact, enable to be hidden in the pants, and the weight is only 1kg. Furthermore, we also developed the tablet software which can tune RE-Gait® easily by medical doctors or physical therapists in a hospital and a care home. RE-Gait® is already used in many hospitals and care homes, and over 300 patients improved their walking gait.

Biography

Eiichiro Tanaka graduated from Tokyo Institute of Technology, and received the Doctor of Engineering. He joined the Mechanical Engineering Research Laboratory in Hitachi Ltd., and after working as a researcher in Hitachi, he joined Hiroshima University, Shibaura Institute of technology, and Saitama University, and so on. He joined Waseda University as a Professor in 2016. His research field is machine elements, and human assistance devices. In 2018, he received the awards of JSME, RSJ, JSDE, and JSWE for RE-Gait®.

Title Design, modeling and analysis of mechanism for assistive exoskeletons

Lecturer Prof. Shaoping Bai, Department of Mechanical and Manufacturing Engineering, Aalborg University, Denmark

Abstract

Exoskeletons as mechatronic systems designed to assist, aid, strength, and help people have very broad areas of applications including health care, elderly assistance, industrial and military uses. In exoskeleton development, mechanism design is critical to achieve a lightweight and compact solution for enhancing their performance of human-exoskeleton interaction and finally their successful deployment.

In this tutorial, design challenges in the exoskeleton development will be outlined. Relevant issues including mechanism synthesis, physical human-exoskeleton interaction simulation and analysis,

design evaluation will be discussed. Design examples of mechanisms for exoskeletons from EU and Danish national projects such as EXO-SUIT, Patient@home, exo-aider, etc, will be represented.

Biography

Dr. Shaoping Bai is an Associate Professor at the department of Mechanical and Manufacturing Engineering, Aalborg University (AAU), Denmark. His research interests include medical and assistive robots, parallel manipulators, walking robots, dynamics and design. Dr. Bai leads several national and international research projects in exoskeletons, including EU AAL project AXO-SUIT and IFD Grand Solutions project EXO-AIDER, among others. He received the best paper awards of IEEE CIS-RAM 2017, IFToMM MEDER 2018 and the Grand Prize of Innovation Challenges, WearRAcon 2018. Dr. Bai is an Associate Editor of ASME J. of Mechanisms and Robotics and an Associate Editor of IEEE Robotics and Automation Letters. He serves as a deputy chair of IFToMM Technical Committee of Robotics and Mechatronics and also a deputy chair of IFToMM Denmark.

Title Development of tailor-made robots and mechanisms with complex joints

Lecturer Prof. Mathias Hueshing, RWTH Aachen University, Germany

Abstract

The design of robots and mechanisms requires type synthesis and dimensional synthesis.
In this tutorial, type synthesis using a complex joints method and an evaluation method for the dimensional synthesis of robots and mechanisms are presented.

Biography

Graduating as Dipl.-Ing. at Leibniz University Hannover with diploma thesis: “Programming of an iterative program system for the kinematic analysis of planar mechanism”
Doctoral Degree in Engineering from RWTH Aachen University in 1995, Title of Dissertation: "Tolerance management of planar mechanisms with regard to their transfer functions"
Since 1995 senior lecturer and senior research associate at the Institute of Mechanism Theory and Machine Dynamics at RWTH Aachen University
Since 2015 Professor at RWTH Aachen University.
He teaches dynamics of rigid bodies and robotic systems at RWTH Aachen University.

Title Solutions on assistive robotics at CESTER-LARM

Lecturer Prof. Giuseppe Carbone, University of Calabria, Italy
Prof. Doina Pisla, Techincal University of Cluj-Napoca, Romania

Abstract

The aging of population and decline of NHS resources in Europe is opening new problems in healthcare that might be conveniently addressed with robotics solutions, in a near future. AGEWELL project aims to provide a viable solution of the (sub)acute therapy for stroke patients. The implementation team aims to deliver a solution that can be extended towards robotic assisted rehabilitation in different phases of the post-stroke therapy/rehabilitation as well as an exercise/training devices for healthy aging of the elderly population. Some proposed solutions are be outlined as referring to LAWEX, ASPIRE, and PaRReX patent pending designs. The structure of LAWEX is a non-conventional cable-driven open architecture, which allows accessibility of patients under treatment. Using wristbands, cables are connected to the end-effector which covers the limb to be trained. ASPIRE is a spherical parallel architecture intended for shoulder assistance as it can

perform multiple feasible shoulder motion ranges. PaRRex can be seen as a wearable exoskeleton with modular structure, consisting of two parallel modules, one for the forearm mobilization (elbow flexion) and the pronation/supination, the second parallel module is designed to mobilize the wrist (flexion/extension and abduction/ adduction).

Biography

Giuseppe Carbone is Associate Professor at DIMEG, University of Calabria, Italy, since Dec. 2018. He has got the Master and Ph.D. degree at University of Cassino (Italy) where he has been working at LARM (Laboratory of Robotics and Mechatronics) since 2000. He has been Visiting Professor at Humanoid Robotics Institute (Waseda University, Japan), Dept. of Mechanical Engineering (University Carlos III Madrid, Spain), Beijing Institute of Aeronautics and Astronautics (Beihang University, Beijing, China), GMSC Department, Pprime Institute (University of Poitiers, France), Centre for Automation and Robotics Research (Sheffield Hallam University, UK). His research interests cover aspects of Mechanics of Manipulation and Grasp, Mechanics of Robots, Engineering Design with over 300 research paper outputs. He has been PI or co-PI of more than 20 projects including 7th European Framework and H2020 funds. Currently, he is Deputy Chair of IFToMM TC on Robotics and Mechatronics, Deputy Chair of the Youth Committee of the International Society of Bionics and Biomechanics, Treasurer of the IFToMM Italy Member Organization. Doina PISLA, is currently the Vice-rector for University Doctoral Studies within the University of Cluj-Napoca, Romania and the Director of the Research Center for Industrial Robots Simulation and Testing - CESTER within the same university.

Professor Doina PISLA, obtained her PhD within the Technical University of Cluj-Napoca in 1997. Following an academic carrier she became full professor at the Department of Mechanical Systems Engineering in 2005. Prof. Pisla's research activity is focused mainly on the field of Robotics and Mechatronics, with emphasis on the Kinematics and Dynamics of parallel robots, Development of Innovative robotic structures for medicine. As a result of her scientific activity, prof. Pisla published over 200 peer-reviewed full papers in scientific journals and conferences, co-authored 15 patents being currently Topic Editor of the Mechanical Science, Copernicus Publication. In the meanwhile she served in boards and program committees of various international conferences, and is currently the member of the Technical Committee for Computational Kinematics and Technical Committee of Biomechanical Engineering of IFToMM.

Recent Bibliography of reference

[1] Carbone G., Ceccarelli M., Pisla D. (Eds), "New Trends in Medical and Service Robotics, Advances in Theory and Practice", Mechanism Machine Science, volume 65, Springer, Cham, 2018.
[2] Carbone G. and Gomez-Bravo F. (Eds), "Motion and Operation Planning of Robotic Systems: Background and Practical Approaches", Springer, London, 2015.
[3] Carbone G. (Ed.), "Grasping in Robotics", Springer, Dordrecht, 2013.
[4] Carbone G., Gherman B., Ulinici I., Vaida C., Pisla D., "Design Issues for an Inherently Safe Robotic Rehabilitation Device", Proceedings of the 26th International Conference on Robotics in Alpe-Adria-Danube Region RAAD 2017, Spinger, Dorchect, pp.967-974, 2017.
[5] Carbone G., Pisla D., Vaida C., Gherman B., Nadas I., "Towards cost-oriented User-friendly Robotic Systems for post-stoke Rehabilitation", Chapter 5 in Handbook of Research on Biomimetics and Biomedical Robotics, IGI Global, Hershey, 2017.
[6] Rodríguez León J.F., Carbone G., Cafolla D., Russo M., Ceccarelli M., Castillo Castañeda E., "Experiences and Design of a Cable-Driven Assisting Device for Arm Motion", 22nd CISM IFToMM Symposium on Robot Design, Dynamics and Control ROMANSY 2018, Rennes, 2018.

[7] Cafolla D., Russo M., Carbone G., “Design and validation of an Inherently Safe cable-driven assisting device”, International Journal of Mechanics and Control, Volume 19, Issue 1, Pages 23-32, 2018. ISSN: 1590-8844
[8] Cafolla D., Russo M., Carbone G., “CUBE, a cable-driven device for limb rehabilitation”, Journal of Bionic Engineering, In Press