2015 IEEE/RSJ International Conference on Intelligent Robots and Systems

IROS 2015 - Gateway to the Era of Robots

Workshop

New Frontiers and Applications for Soft Robotics

October 2, 2015, Hamburg, Germany

Organisers: Matteo Cianchetti, Helmut Hauser, Fumiya Iida, Jonathan Rossiter, Laura Margheri and Cecilia Laschi

http://www.robosoftca.eu/events/iros-2015-workshop

Objectives

The one day Workshop on “New Frontiers and Applications for Soft Robots” will attract experts across multiple fields in the soft robotics community and will be a unique occasion to gather the most prominent scientific actors of the field and industrial representatives.

Soft robotics research is providing interesting achievements and there is a general opinion that it can find application in many diverse industrial sectors. This workshop will help focus on the needs from industry and services, that may find responses from soft robotics. To this aim, invited speakers not only from academia but also from industry will present and discuss real issues, concrete scenarios and possible applications where soft robotics can represent a game changer.

Thanks to the high interdisciplinarity of the field of soft robotics the event will gather together researchers with different scientific backgrounds, as well as stakeholders and industrial companies active in the field or interested in soft robotics applications. This workshop will contribute to the networking of the community and will foster collaborative activities necessary to promote those aspects of soft robotics that are still at an early stage of development and will also start to fill the gap between laboratory and industrial products.

The workshop agenda includes talks and roundtable sessions, as well as poster sessions during the breaks, to foster discussion among participants, identify needs, promote collaborations and ideas for using soft robots as companions in daily tasks and especially in those areas that are off limits for traditional rigid robots.

The workshop is organized to be part of the series of scientific events planned in the framework of RoboSoft Coordination Action (EU funded project, under the FET open scheme, http://www.robosoftca.eu/) aimed at bringing together worldwide researchers and industrial leaders to enable the step-change in technologies and standards needed to advance soft robotics and its marketing. The event is also supported by the IEEE RAS Technical Committee on Soft Robotics.

Topics

- Soft actuators
- Soft and flexible sensors
- Stretchable electronics
- Highly deformable smart materials
- Energy harvesting devices based on soft materials
- Modelling and simulation techniques of soft bodies
- Control of soft robots
- Scientific issues related to soft-bodied robots
- Soft robotics applications

Program

Opening Matteo Cianchetti, Scuola Superiore Sant'Anna	**8:30 - 8:50**
Soft Robotics: from bioinspiration to scientific challenges and technological applications Cecilia Laschi, Scuola Superiore Sant'Anna	**8:50 - 9:10**
Stiff Flop project. Hardware and software integration Rich Walker, Shadow Robot	**9:10 - 9:40**
Soft Robotics and Agriculture - possible use cases and benefits Benno Pichlmaier, AGCO	**9:40 - 10:10**
Coffee Break and Poster Session	**10:10 - 10:50**
Energetic soft robotics: going beyond the battery Jonathan Rossiter, Univeristy of Bristol	**10:50 - 11:20**
Inherently Soft - Inherently Safe: Next Generation Robots for Minimally Invasive Surgery Kaspar Althoefer, King's College of London	**11:20 - 11:50**
Leveraging Body Compliance for Autonomous Applications Robert Katzschmann, MIT	**11:50 - 12:20**
Roundtable discussion I moderator: Nicola Nosengo	**12:20 - 12:50**
Lunch Break	**12:50 - 14:00**
Modular Design Approach for Soft Robotics Kyujin Cho, Seoul National University	**14:00 - 14:30**
Active Elastic Skins for Soft and Wearable Robots Rebecca Kramer, Purdue University	**14:30 - 15:00**
Understanding aquatic propulsion using multi-material flexible prototypes Li Wen, Beihang University	**15:00 - 15:30**
Coffee Break and Poster Session	**15:30 - 16:10**
Highly Stretchable Artificial Skin Sensors for Soft Robotic and Wearable Applications Yong-Lae Park, Carnagie Mellon University	**16:10 - 16:40**
Pneumatic Soft Actuator: Planar, Printable, Playful Ryuma Niiyama, University of Tokyo	**16:40 - 17:10**
Roundtable discussion II moderator: Nicola Nosengo	**17:10 - 17:40**
Wrap up and closing	**17:40**

Soft Robotics: from bioinspiration to scientific challenges and technological applications

Cecilia Laschi
Scuola Superiore Sant'Anna, The BioRobotics Institute, Italy

Soft robotics has strong roots in bioinspiration, as the observation of living beings clearly showed to roboticists the way how soft tissues can help negotiate natural environments, using smart adaptation strategies and implementing the embodied intelligence, or morphological computation, paradigm. Using soft materials for building robots poses new technological challenges: the technologies for actuating soft materials, for embedding sensors into soft robot parts, for controlling soft robots are among the main ones. This is stimulating research in many disciplines and many countries, such that a wide community is gathering around initiatives like the IEEE TAS TC on Soft Robotics and the RoboSoft CA – A Coordination Action for Soft Robotics, funded by the European Commission. Though still in its early stages of development, soft robotics is finding its way in a variety of applications, where safe contact is a main issue, in the biomedical field, as well as in exploration tasks and in the manufacturing industry. And though the development of the enabling technologies is still a priority, a fruitful loop is growing between basic research and application-oriented research.

Stiff Flop project. Hardware and software integration

Rich Walker
Shadow Robot, UK

Description of the Stiff flop surgical robot. Challenges of integrating soft robots in ROS (Robot Operating System): robot representation, control strategy, IK method. Hardware integration using Ronex general input/output modules.

Soft Robotics and Agriculture - possible use cases and benefits

Benno Pichlmaier
AGCO, Germany

Farmers are operating in a natural environment. Animals, fruits, vegetables, plants in general, as well as soil interaction in various processes set the stage. It seems obvious that bio-inspired and soft robotics approaches go along well with these surroundings. And in fact, some of the tedious manual tasks could not be automated so far due to mainly two reasons: too complex control algorithms and lack of suitable manipulators. At least the second issue can be addressed through new soft robotics ideas. This contribution will focus on possible use cases in the area of tire-soil interaction and vegetable harvesting and give a general introduction to agricultural robotic needs and opportunities.

Energetic soft robotics: going beyond the battery

Jonathan Rossiter
University of Bristol, UK

It is a truism that all robots, like their biological counterparts, need energy to operate. On the other hand, the form of energy, the way it is used and the consequences of the energy choice result in a rich space of options to explore in the design of any robot. Soft robots are particularly suited to use with a wide range of energy sources. Additionally the great flexibility in design and materials choices - both passive and active - in soft robotics means that components and even complete robots can exploit novel electrical, chemical and mechanical mechanisms to minimize or optimize energy use. In this presentation we will examine how efficient energy use and energy autonomy can be tackled in soft robots. This includes organic energy sources, electro-active, photo-active and chemo-active soft materials and complete energy-autonomous soft robots. We will present recent advances in energetic soft robotics as demonstrated by adaptive soft structures and bio-inspired and environmentally-interacting soft robots.

Modular Design Approach for Soft Robotics

Kyu Jin Cho
Seoul National University, Korea

Soft robotics tries to overcome the limitations of traditional rigid body robots using soft and flexible structures. One of the merits of the soft robotics is it’s adaptability to various environments that the robot interacts with. In this talk, a concept of modular design approach for soft robotics by using air-cell units will be presented. The new design makes it simple to modify the structure of a fully assembled soft robot; air-cell units and entire modules can just be pulled out from the structure and plugged into a different place for change of function, form, or for repair of broken parts. The modular design approach increases the flexibility of the soft robot design which in turn could increase adaptability of the robot to various environments.

Highly Stretchable Artificial Skin Sensors for Soft Robotic and Wearable Applications

Yong-Lae Park
Carnagie Mellon University, USA

The development of highly deformable artificial skin sensors is a key technology to advance various future robotics areas, such as soft robotics, wearable computing, haptics, and humanoids. Conventional force sensors, such as multi-axis load cells and piezo-resistive pressure sensors, have been widely used in traditional robots made of mostly rigid materials and structures. However, future robots and robotic systems will contain or consist of highly compliant materials in their mechanical structures for increased human safety, friendliness, and interactions, requiring a new type of sensing schemes for both proprioceptive and exteroceptive feedback. To meet this requirement, we have been investigating various soft artificial skin technologies focusing on hyperelastic materials with embedded sensing capabilities. In this talk, I will discuss recent advances on artificial skin sensors, including i) microfluidic soft sensing, ii) stretchable optical waveguides, and iii) fiber optic force and tactile sensing, with an emphasis on soft robotic and wearable applications. I will also discuss novel 3-D fabrication processes for multi-material, soft smart structures.

Leveraging Body Compliance for Autonomous Applications

Robert Katzschmann
Massachusetts Institute of Technology, USA

The use of body compliance and softness in robotic applications requires new approaches to design, fabrication and control. This talk is about how we model, characterize, combine, fabricate and control various types of fluidic elastomer actuators to make best use of them for robotic prototypes. That is, three actuator morphologies composed entirely from soft silicone rubber are discussed and several casting-based and 3D printer-based fabrication processes are explored to build and then control complete systems for manipulation and underwater locomotion.

Active Elastic Skins for Soft and Wearable Robots

Rebecca Kramer
Purdue University, USA

As advanced as modern machines are, the building blocks have changed little since the industrial revolution: structure, motors and gears are typically rigid, bulky and heavy. Future machines will be soft, elastically deformable and lightweight, lending them to applications such as soft robots, conformable wearable devices, and safe human-machine interfaces. Progress toward these next-generation soft machines is an interplay between the development of new soft active materials for actuation and sensing, adaptive controllers that will account for the non-linear and time-varying behaviors displayed by soft materials, and scalable manufacturing processes for soft materials. This talk will highlight the work of the Purdue Faboratory in developing processes, techniques, and tools for active elastic/soft skins that will enable lightweight, compact, robust, and reconfigurable soft and wearable robots.

Understanding aquatic propulsion using multi-material flexible prototypes

Li Wen
Beihang University, China

The current studies of fish-like aquatic propulsion are quite limited in their ability to control for physical determinates such as body shape, kinetic motions, flexural stiffness, skin surface scale and Mucus properties etc. Keeping one of these determinates constant while altering others in a controllable manner is impossible for the swimming live fishes. Bio-inspired robotic models offered the ability to manipulate and control individual physical determinate that affect the aquatic propulsive performance. In collaboration with a number of colleagues at Harvard University, we have developed bio-inspired robotics as well as multi-material prototypes to experimentally investigate several new topics of aquatic propulsion. A key feature of our underwater experimental setup is that the bio-inspired robotics and multi-material prototypes are self-propelled (thus to satisfy Newtonian equation of balance) and can swim against the flow in the lab water tank. While self-propelled swimming, measurement of speed, external forces and torques, internal power consumptions, cost-of-transport (COT) of the bio-inspired robot and the multi-material prototypes are synchronized with the motion program and high-speed video of the wake flow. Based on the experimental setup, I will present two main scientific topics of fish biomechanics: (1) the hydrodynamic effect of a synthetic, flexible fish (Mako shark, Isurus oxyrinchus) skin prototype which is fabricated by using the state-to-art multi-material 3D printing and test by using the "self-propelled" robotic device, and (2) hydrodynamic swimming performance of a fish skin mucus inspired engineering lubricant coated prototype, which has micro-nano textured solid substrate to hold high-viscosity slippery liquid on the top. Selected results from these studies will be discussed in detail to illustrate the utility of bio-inspired robotics and multi-material prototypes for revealing novel features of the biomechanics of fish swimming and aquatic propulsion.

Inherently Soft - Inherently Safe: Next Generation Robots for Minimally Invasive Surgery

Agostino Stilli / Helge Wurdemann / Kaspar Althoefer
King's College of London, UK

In my presentation I will provide an overview of research on soft and stiffness-controllable robot manipulators for surgical applications. With a view at creating safe robots for minimally invasive surgery (MIS), my team and I at the Centre for Robotics Research (CoRe) aim to design and realise robotic systems capable of varying their structural stiffness from soft to stiff. Inspired by biology, our robot systems are modelled after the limbs of the octopus. Departing from the traditional approach of using rigid tools, we embrace the new concept of soft and stiffness-controllable robots for MIS. In my talk, I will discuss the advantages of the proposed robot systems and the challenges that lie ahead to create safe robot systems that can be employed in the operating theatre of the future.

Pneumatic Soft Actuator: Planar, Printable, Playful

Ryuma Niiyama
University of Tokyo, Japan

We introduce a pouch motor: a pneumatic soft actuator that is suitable for automated mass-production. The actuator consists of one or more inflatable gas-tight bladders made of sheet materials. A custom-built CNC fabrication machine is developed for flexibility in design. We implement a printable pneumatic artificial muscle (PAM) based on this technique. We demonstrate a prototype of bionic arm driven by the printable PAMs and also an animated origami robot kit for kids.

Abstracts accepted as poster presentation during the workshop

(alphabetic order)

Advancements in Position Control of Pneumatic Muscle Actuators	George Andrikopoulos, George Nikolakopoulos and Stamatis Manesis
Soft and Functional Material Research at the Faboratory	Adam R. Bilodeau, William J. Boley, Jennifer C. Case, Edward L. White, Michelle C. Yuen and Rebecca K. Kramer
Monolithic Fabrication of Sensors and Actuators in a Soft Robotic Gripper	Adam R. Bilodeau, Edward L. White and Rebecca K. Kramer
Measurement of Tissue Stiffness Using Soft eGa-In Sensors and Pressure Application	Nicholas P. Bira and Yiğit Mengüç
Double Dielectric Elastomer Balloon Actuators Network	Feifei Chen and Michael Yu Wang
Feasible Modelling Approaches for Thick Continuum Robots. A Planar Experimental Study	Bastian Deutschmann and Christian Ott
A Biomimetic Scansorial Foot Design for Soft-Bodied Robots	Cassandra Donatelli, Nikolas Kastor and Barry Trimmer
Learning to Exploit Morphology for Control and Computation	Martin Garrad and Helmut Hauser
Stretchable liquid alloy antennas for wireless communication	Seung Hee Jeong, Zhigang Wu and Klas Hjort
Semi-autonomous Soft Robotic Platform for Terrestrial Locomotion	Nikolas Kastor, Maxwell Hill, Vishesh Vikas, Robert D. White and Barry Trimmer
Soft Actuators by Densely Packing Circular Fibers	Samuel Laney and Joshua Schultz
Development of a Pneumatically Powered Modular Soft Actuator Assembled from Multi-Material 3D-Printed Air-Cell Units	Jun-Young Lee and Kyu-Jin Cho
Slithering Towards Autonomy: Evolution of the WPI Soft Robotic Snake	Ming Luo, Erik H. Skorina, Weijia Tao, Fuchen Chen and Cagdas D. Onal
Learning from demonstration for Bionic Handling Assistant robot	Milad S. Malekzadeh, J. F. Queißer and J. J. Steil
Investigation of suitable solutions for variable stiffness mechanisms	Mariangela Manti, Matteo Cianchetti and Cecilia Laschi
Flexible Design of a Printable Planar Pneumatic Actuator	Ryuma Niiyama, Shih-Yin Chang and Yasuo Kuniyoshi
Template based virtual model control of hopping motions approaching elastic behavior in a segmented robotic leg	Jonathan Oehlke, Maziar Ahmad Sharbafi and Philipp Beckerle
Hybrid robotic system for applications in robotic surgery	Gabrijel Smoljkic, Gianni Borghesan, Dominiek Reynaerts, Joris De Schutter, Jos Vander Sloten and Emmanuel Vander Poorten
Introducing a Green Material in Soft Robot Design	Steph J. Walker and Yigit Mengüç
Nonlinear Cerebellar-Inspired Adaptive Control Applied to a Dielectric Electroactive Polymer	Emma D. Wilson, Tareq Assaf, Martin J. Pearson, Jonathan M. Rossiter, Paul Dean, Sean R. Anderson and John Porrill

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