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Yoseph Bar-Cohen
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Introduction

This SPIE's Electroactive Polymers Actuators and Devices (EAPAD) Conference is the leading international forum for presenting the latest progress and holding discussions among the attendees regarding the capabilities, challenges and potential future directions. The conference this year was co-chaired with Barbar J. Akle, Lebanese American University, Lebanon, and included 141 presentations, which has been a record number.

The Conference was well attended by internationally leading experts in the field including members of academia, industry, and government agencies from the USA and overseas. This year the Keynote speaker was Robert Shepherd, Cornell, and the titled of his talk is titled "Soft robotics: a review and progress towards faster and higher torque actuators". In his presentation he highlighted that the field of soft robotics is taking advantage of compliant actuators and passive dynamics to achieve several goals: reduced design, manufacturing and control complexity, improved energy efficiency, more sophisticated motions, and safe human-machine interactions to name a few. In his presentation he described the potential for combinations of different classes of soft actuators (e.g., electrically and pneumatically actuated systems) to improve the utility of soft robots and their potential impact.

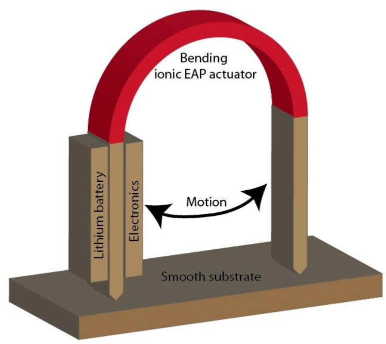
Significant progress was reported in each of the topics of the EAP infrastructure with focus on such areas as energy harvesting, biomimetics, haptics, braille displays, and miniaturization. The papers addressed issues that can forge the transition to practical use, including improved materials, better understanding of the principles responsible for the electromechanical behavior, analytical modeling, processing and characterization methods as well as considerations and demonstrations of various applications. The Special Session this year was dedicated to the topic of Electroding Materials and Systems. Other topics that were covered in this conference included:

- Electroactive polymers (EAP) and non-electro active-polymer (NEAP) materials
- Theoretical models, analysis and simulation of EAP.
- Methods of testing and characterization of EAP
- EAP as artificial muscles, actuators and sensors
- Design, control, intelligence, and kinematic issues related to robotic and biomimetic operation of EAP
- Under consideration and in progress applications of EAP

The efforts described in the presented papers are showing significant improvements in understanding of the electromechanical principles and better methods of dealing with the challenges to the materials applications. Researchers are continuing to develop analytical tools and theoretical models to describe the electro-chemical and -mechanical processes, non-linear behavior as well as methodologies of design and control of the activated materials. EAP with improved response were described including dielectric elastomer, IPMC, conductive polymers, gel EAP, carbon nanotubes, and other types. Specifically, there seems to be a significant trend towards using dielectric elastomers as practical EAP actuators.

This year, the conference included a half-day course about electroactive polymers, and the instructors were Yoseph Bar-Cohen, Jet Propulsion Lab/Caltech., Pasadena, CA; John Madden, U. of British Columbia, Vancouver, Canada; and Qibing Pei, University of California, Los Angeles. Also, an EAP-in-Action Session was held and it consisted of the following nine demonstrations with presenters from Estonia, Germany, Japan, New Zealand, Switzerland, United Kingdom, and USA. The presentation of 9 demonstrations has been a record for the EAPAD Conference.

Bio-inspired autonomous robot actuated by ionic EAPs - Indrek Must, Friedrich Kaasik, Inga Põldsalu, Lauri Mihkels, Urmas Johanson, Andres Punning, Alvo Aabloo; Intelligent Materials and Systems Lab (http://www.ims.ut.ee), University of Tartu (Estonia)



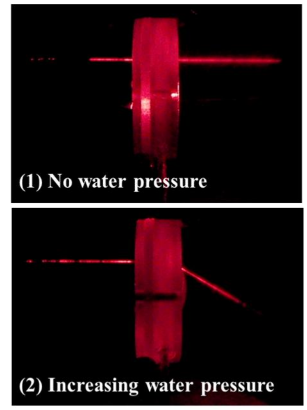
An autonomous crawling microrobot with locomotion inspired by an inchworm and propelled by ionic liquid-based bending EAPs was presented. This microprocessor-controlled robot was powered by an on-board lithium battery and is able to move in ambient air on a smooth surface. The construction takes advantage of the unique properties of soft EAP technology.

DEA enhanced PC-mouse for improving human machine interaction -
Henry Haus, Holger Mößinger, and Helmut F. Schlaak, Technische Universität Darmstadt (Germany)

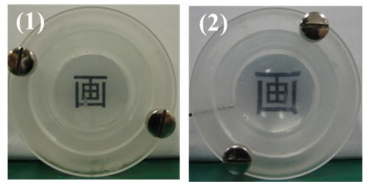
The flexibility of rubber-like dielectric elastomer actuators allows adjusting the shape of tactile interfaces to fit onto arbitrary surfaces. This flexibility offers the opportunity to provide tactile stimulus not only the fingertips but also to other parts of the human body, using greater parts of the human skin to transmit information. A fully functional PC-mouse, enhanced with DEA technology, providing tactile feedback into the palm of the user hand was demonstrated. The audience was offered to try out the tactile feedback while interacting with specially designed demo software on a PC, giving everyone the opportunity to experience the advantages of flexible DE-actuators for human machine interaction.

Smart Gel Robotics with Flexible & Transparent Shape Memory Gel (FT-SMG)

Jin Gong, and Hidemitsu Furukawa, Yamagata University (Japan)



A smart varifocal lens is designed with flexible & transparent shape memory gel (FT-SMG), which freely adjusts the focal length based on simple mechanism of changing water pressure inside. Except for a soft eye of a robot, we have also developed other FT-SMG gel for robots including soft touch paper and soft skin finger.



Wearable and portable energy harvesters and soft sensor technologies

Presenters: Iain Anderson[1, 2], Thomas McKay[1], Daniel Xu[1], Andrew Lo[1], Tony Tse[1], Todd Gisby[2]

[1] Biomimetics Laboratory and [2]StretchSense Ltd, Auckland, Contact:
Iain A. Anderson, Biomimetics Lab (New Zealand)
[2]Stretchsense Ltd (New Zealand)

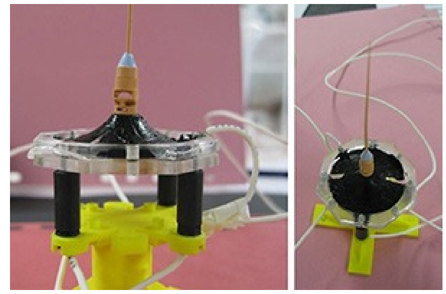
The Biomimetics Lab and the new spinoff StretchSense Ltd. have demonstrated advances leading to an exciting future of wearable and portable energy harvesters and soft sensor technologies that include a wireless glove.

(1) Getting low voltage power from a dielectric elastomer generator (DEG) is now possible. The developed electronics is specifically designed for small portable DEGs that are capable of efficiently transforming high voltage to low voltage.

(2) To get the most out of a DEG, its mechanical strain should be sensed. The best way to do this is to monitor the elastomer directly: to self-sense. The DEGs can now self-sense, simultaneously harvesting energy and sensing mechanical state without the need for bulky sensors.

(3) Measuring human body motion can provide valuable feedback for sports, medical, video and game applications. The next generation of soft sensor technologies, including a wireless glove, will be presented.

DEA-Based Whisker for Robotics - Tareq Assaf, Jonathan Rossiter, Andrew Conn, Martin Pearson, and Peter Walters, Bristol Robotics Lab. (United Kingdom)



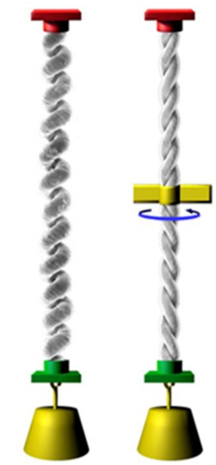
DEA-based whisker module was presented showing the results of the efforts to scale and overcome critical issues for the exploitation of this artificial muscle technology in robotics, in particular as actuator to drive active tactile sensing. The modularity, dimensions, low weight and soft features make of this technology ideal for such application with relatively easy access to 2 Degrees of freedom and achieving both actuator and sensor capabilities. During the demonstration the prototypes were shown and actuated together with the new upcoming release that contains improvements both on the design and performance point of view.
Acknowledgement: The DEA-based whisker module has been developed under the BELLA Project funded by EPSRC under grant EP/I032533/1

High speed silicone DEAs - S. Rosset, S. Araromi, A. Poulin, L. Maffli, J. Shintake, and H. Shea**,** École Polytechnique Fédérale de Lausanne (Switzerland)

µm- to cm-scale dielectric elastomer actuators will be presented. Processes to manufacture DEAs were developed with a high quality and reliability. Llarge area silicone membrane casting and precise patterning of electrodes allows producing small-scale and robust DEAs with a high yield. Different functioning devices will be demonstrated, such as a 4 fingers multi-segment gripper, seen in the photo grabbing a mockup of EPFL’s SwissCube. This DEA-based gripper is a soft-actuator candidate to be mounted on CleanSpace One, the EPFL’s next satellite whose task is to demonstrate the possibility of orbital debris removal by capturing and deorbiting the now-decommissioned SwissCube [http://space.epfl.ch/page-61745-en.html].

Carbon-Based Tensile and Torsional Artificial Muscles - Carter S. Haines, Marcio D. Lima, Ray H. Baughman, University of Texas at Dallas

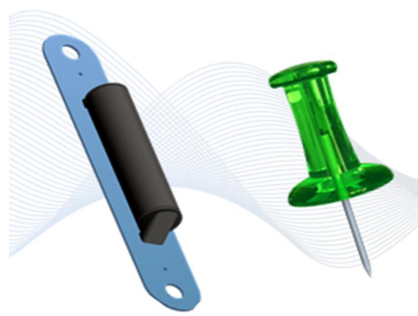
Carbon-based artificial muscles have been designed to provide fast torsional and tensile actuation. In tension, these muscles can provide in excess of 20% stroke without hysteresis when powered electrically or by using hot liquids such as water. More than a million cycles of reversible tensile actuation have been performed without a significant loss of performance. Torsional muscles that can move heavy loads and operate from ambient temperature gradients have also been shown. Such muscles can be woven into braids and fabrics to produce smart textiles and actuating fabric. Demonstrations include torsional and tensile muscles exhibiting large stroke and giant force performance.



Schematic of torsional and tensile muscles produced from carbon-

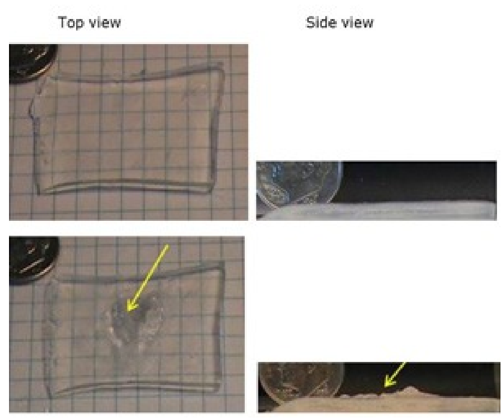
ViviTouch® HD Feel enables advanced and multi-dimensional communication through touch - Dirk Schapeler, ViviTouch, A Bayer Brand

An EAP stacked actuator was demonstrated that is smaller than a thumb tack that is easily integrated as wearable devices and unique spaces. It can be used as a bracelet or line clothing, in trigger buttons or thumb sticks, in a game controller for direct contact with skin as well as individually controlled haptic feedback zones. The device provides high definition feel with a broad spectrum of haptic effects having silent operation and without any audible buzzer.



Synthetic Muscle™: EAP-based materials and actuators - Lenore Rasmussen and Eric Sandberg, (United States)

The most recently enhanced EAP material called Synthetic Muscle TM was demonstrated contracting and expanding. The material can be activated in a controlled zone (the photos show expansion in the middle of the film) offering the potential of haptic interfacing with programmable reasons.



In closing, I would like to extend a special thanks to all the conference attendees, session chairs, the EAP-in-Action demo presenters, the members of the EAPAD program organization committee. In addition, special thanks are extended to the SPIE staff that helped making this conference a great success.

Yoseph Bar-Cohen