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Introduction

Goals of this Conference

Due to the proliferation of mass-produced, miniaturized sensors, it is now possible to envision massively distributed sensors being used to enhance perception, cognition, and control capabilities of next-generation robots. In fact, applications where new, more intelligent robots are needed cut across all dimensional scales and industrial sectors. Examples include assisted living environments, search and rescue in disaster areas, neural and vision prosthetics, nano-manufacturing, self-driving vehicles, human-friendly industrial assembly and smart material handling, and so on. One exciting next-generation application is endowing humanoid robots with perception comparable with those of humans: including not only distributed touch through robotic skin, hearing, and vision, but also super-human perception, such as the ability to see in the dark or through objects. Using off-the-shelf sensors that have not been designed specifically for robotics is fraught with challenges that must be mitigated by consideration of power, weight, form factor, and interconnections early in the design process.

This conference focuses on new sensors and sensor arrays for robotics and autonomous vehicles, new form factors and packaging schemes to help integrate robots and sensors, new applications of robots enabled by increased perception capabilities, and challenges in sensor fusion, networking and control brought about by massive amounts of sensor data available to the robot. The conference promotes technical scientific papers related to robot sensors that push beyond the state-of-the-art in industry and new robotics applications, including those with dual uses (e.g., military-defense and commercial-industrial).

Summary of the Third Conference

The third Sensors for Next-Generation Robotics conference was held at the SPIE Defense+Commercial Sensing (DCS) symposium in Baltimore, Maryland, United States on April 20-21, 2016. The poster entitled “Piezoresistive pressure sensor array for robotic skin” was presented by Fahad Mirza, a graduate student at the University of Texas at Arlington (United States), and Mirza discussed the experimental results with printed arrays of piezo-resistive strain gauges and embedded silicone polymers. These sensors have applications, such as touch sensitive whole body robot skin for the next-generation service and assistive robots that are soft, safe and collaborate with humans. The work was documented in proceedings paper 98590K [9859-15].

On April 21st, presentations were organized in three tracks dedicated to small-scale robotics, human-size assistive robots, and autonomous vehicles. The morning session consisted of the following speakers:

- Anne Schneider of Robotics Research, LLC (United States) spoke of perception sensor studies for ground vehicles. This was a very important experimental study evaluating three commercially available lidar units for figures of merit relevant to their use in robotic ground vehicles. This study was a continuation of their work presented at the SPIE STA 2015 conference, and was documented in paper 985902 [9859-1].

- Jim Hollinger of Land Sea Air Autonomy, LLC (United States) spoke of evaluating the return signals of lidars due to secondary reflections from objects covered in foliage. Unlike airborne imaging, the reflections considered in this study came from objects considerably closer together than the tree canopy to ground, therefore measurement resolutions will be considerably different. Eventually, this study will be important when deploying this technology on ground autonomous vehicles. This presentation continued work presented at SPIE STA 2015, and was documented in paper 985903 [9859-2].

- Sven Cremer, a graduate student at the University of Texas at Arlington (United States), presented his work on evaluating the performance of a human-robot interface with a mobile manipulator. Such manipulators consist of a mobile base and a multi-degrees of freedom arm, which can be operated remotely from a tablet or with direct contact using pressure-sensitive robot skin. This study is important to future applications of this technology in service robots for homes, and it is a continuation of work presented at SPIE STA 2015, which was documented in paper 985904 [9859-3].

- Sumit Das, a graduate student at the University of Louisville (United States), presented his work on creating and validating a Finite Element Model for packaged pressure sensitive skin sensors. These models are important for designing and evaluating application specific sensors and sensor arrays prior to fabrication. The work was documented in paper 985905 [9859-4].

- Indika Wijayasinghe, research associate at the University of Louisville (United States), presented his work on calibrating optical sensing systems measuring the eye gaze and head pose of humans and humanoid robots. His work synchronized data from three separate motion capture systems and used it to develop advanced controllers for android robots that resemble human capabilities. This work was documented in paper 985906 [9859-5].

- Jeremy Straub, a graduate student at the University of North Dakota (United States), presented his work on using a multi-camera system to retrofit 3-D printers in order to reduce defects and improve the quality of manufactured objects.

- Micky Rakotondrabe, Professor at FEMTO-ST Institute in Besancon, France, presented his work on the improved circuit design for piezo-electric energy harvesters. This work can lead to very exciting applications, as harvesters can be placed on vibrating/moving machinery, robots, and vehicles to power remote sensors. This work was documented in paper 985908 [9859-7].

- Yasser Al Hamidi, a graduate student at Texas A&M University of Qatar (Qatar), presented his work on comparing input shaping methods for control of flexible structures. This technique is particularly useful when controlling next generation robots that are flexible. Furthermore, they can be very useful whenever adding feedback sensors is not possible, such as in the case of micro and nano robots. This work was documents in paper 985909 [9859-8].

- Abdenbi Mohand Ousaid, Professor at FEMTO-ST Institute in Besancon, France, presented his work on a 5 Degrees of Freedom piezoelectric positioner. His research will lead to novel, 3D-printed stages for nanopositioning applications, such as inside SEM and AFM. This work was documented in paper 98590A [9859-9].

Professor Robert Cohn from University of Louisville (United States) gave the exciting keynote presentation entitled "Ultraflexible nanostructures and implications for future nanorobots," which is documented in paper 98590B [9859-20]. His presentation offered an intriguing perspective on types of actuators that are physically realizable at the nanoscale, in particular polymeric nanoactuators that experience contraction under laser irradiation or "cable-like" nanorods that are flexible and amplify motion. Numerous examples of nanostructures from Professor Cohn's laboratory were provided along with representative figures of merit, such as force output, displacement, and bandwidth. This presentation spurred discussion and perhaps future collaborations between robotics, MEMS, and nanotechnology researchers to create the next-generation nanoscale robots with applications in biology and manufacturing.

The afternoon session of the conference focused on new sensors for multiscale robotics applications from the micro scale to the human scale. Speakers included:

- Ryan Landrith, Research Scientist at the University of Texas at Arlington Research Institute (United States), who gave a talk about fabrication and evaluation of microchannel electrode arrays for neural interfaces. MEMS fabricated electrodes can be implanted and electrically connected with peripheral nerves for recording and stimulation, as demonstrated in animal trials, and they will be used by amputees to control prosthetic devices. This work was documented in paper 98590C [9859-10].

- Yasser Al Hamidi, a graduate student at Texas A&M University of Qatar (Qatar), who presented his ongoing work on using input shaping techniques to improve the control of 2 Degrees of Freedom piezoelectric tube actuators. These actuators are used in precision instruments like Atomic

Force Microscopes, and they currently require electronic control and optical feedback sensors to achieve high positioning accuracy. Input shaping can improve the performance of these positioners, and this was documented in paper 98590D [9859-11].

- Jeongsik Shin, Senior Research Scientist at the University of Texas at Arlington Research Institute (United States), who presented his work on design requirements for Adaptive Robotic Nurse Assistants (ARNA), a next-generation robot that will be able to assist nurses and patients with mundane tasks, such as taking vital signs, fetching objects, and rehabilitation exercises. Paper 98590E [9859-12] focused on robot hardware, software, and sensor requirements to fulfill the roles of patient sitter and patient walker.

- Micky Rakotondrabe of FEMTO-ST Institute in Besancon, France, presented the work of his colleagues on design modeling and simulation of three layers piezoelectric cantilevers. Advanced cantilever structures contain two actuation layers utilizing PZT laminates and one sensing layer utilizing PVDF. As a result, the structure can be controlled using feedback with a sensor co-located with the actuator, possibly replacing large, external optical or capacitive transducers. This work was documented in paper 98590F [9859-13].

- Professor Abdenby Mohand Ousaid of FEMTO-ST Institute in Besancon, France, presented the work of his colleagues aimed at creating the next force sensing technology for robots. The novel multi-axis force sensor uses piezoelectric resonance as a transducer, and it is intended to replace commonly used strain-gauge sensors currently used in robot end-effectors. This work was documented in paper 98590H [9859-17].

- Professor Cindy Harnett from the University of Louisville (United States), who presented her pioneering work in creating flexible circuits for shape sensing, which are manufactured by "weaving" them into electronic fabrics. Applications include smart garments for next-generation flexible or soft robots and digital actuation systems that exploit bi-stable microstructures. Her work was documented in paper 98590I [9859-18].

- Oguz Yetkin, a graduate student at the University of Texas at Arlington (United States), who presented his work on a novel fingernail optical sensor to detect "pinch" gestures and drive prosthetic devices from an amputee's sound hand. Paper 98590J [9859-19] detailed experimental results to classify eight different pinch gestures with users evaluating the system.

We hope that readers find our 2016 conference proceedings interesting and will join us at next year's edition of the conference.

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