Plenary Speakers

Koichi Suzumori

Tokyo Institute of Technology

Soft robots as an E-kagen artifact

Wednesday 25
9:00 – 10:00
Conference & Meeting Centre Pancaldi Hall

I have developed various types of soft actuators and robots since 1986. In this presentation, first, I will talk about several examples of my works on soft robotics, which include (1) pneumatic rubber actuators, (2) their medical applications, (3) functional rubber surfaces, and (4) hose-free pneumatics. Next, I will talk about my current works of thin soft muscle and its applications to (1) soft power support suits, (2) musculo-skeletal robots and (3) Giacometti robots. At the end of my talk I would like to talk about the significance of soft robotics in the history of robotics using a Japanese word “E-kagen”, which has two opposite meanings. One is positive meaning of good, proper and moderate and the other is negative meaning of irresponsible, imprecise and vague.

BIOSKETCH
Koichi Suzumori received the Ph.D. degree in mechanical engineering from Yokohama National University in 1990. He had worked for Toshiba R&D Center from 1984 to 2001, and also worked for Micromachine Center, Tokyo from 1999 to 2001. He had been a Professor of Division of Industrial Innovation Sciences, Okayama University from 2001 to 2014. He has been a Professor of Department of Mechanical Engineering, Tokyo Institute of Technology since 2014. He established a venture company, s-muscle Co., Ltd. in 2016, which puts soft thin artificial muscles into practical uses.

Paolo Dario

The BioRobotics Institute, Scuola Superiore Sant'Anna

Soft Robot Companions: How Science Fiction May Become Reality

Thursday 26
9:00 – 10:00
Conference & Meeting Centre Pancaldi Hall

The next generation of robots will realize longstanding visions of robotics researchers and also of industry, transforming daily life on a scale potentially comparable to the internet. Several roadmaps exist, which try to devise the development of future generation robots and how they may become pervasive in our life. However, roadmaps are usually not effective in predicting disruptive innovations. For example, the Moore's law has been useful to devise the evolution of electronic circuits, but not at all to predict the revolution driven by MEMS-based smartphones. In this context, science fiction can be considered a useful tool and a source of inspiration, allowing to imagine how the potential of robots (included soft ones) can be pushed forward.
Several driving factors and Grand Challenges that may revolutionize robotics can be identified, such as:
1. Pervasive sensors INSIDE the robot, pushing their ability to perceive, understand and respond to what is going on around it.
2. Radical transformation of robot bodies, going beyond mechatronics design and emulating soft living beings: there are no bearings in nature, but rather locally deformable structures, such as an insect's leg or wing structure. Taking inspiration from the morphology and organizational principles of living things is opening up a huge variety of novel designs and materials for next-generation robots, including soft and flexible exteriors that can morph into different shapes for different tasks. The use of novel multifunctional materials will enable not only unprecedented robot performance, but will also allow to build low power consumption, sustainable systems.
3. Robots are becoming more integrated with the web, which is shifting the focus of research from autonomy to connectivity. There is less need for them to understand their environment by means of local computational resources, and more scope for them to access the information and instructions they

need from the cloud. And once robots are permanently connected, we can design them for almost any application imaginable, without –of course- neglecting a thorough investigation of related ethical, societal and legal implications.

4. Significant progress has been made in machine learning and artificial intelligence, in particular with the introduction of new powerful methods such as deep learning, enabling new levels of interaction and cooperation between humans and unstructured environment. In the future new paradigm designs will leverage on the new soft bodies and distributed sensing and actuation.

This lecture will describe how science fiction can help to imagine future innovation in this field and how it is possible to further push the boundaries of research in robotics, opening tremendous opportunities for industrial development and practical deployment for societal application.

BIOSKETCH

Paolo Dario received his Dr. Eng. Degree in Mechanical Engineering from the University of Pisa, Italy, in 1977. He is currently Professor of Biomedical Robotics at the Scuola Superiore Sant'Anna in Pisa, and teaches course in the M.S. Program in Bionics Engineering jointly organized by the University of Pisa and by the Scuola Superiore Sant'Anna. He is also the Coordinator of the PhD Program in BioRobotics at the Scuola Superiore Sant'Anna. He has been visiting researcher and professor at Brown University, EPFL, College de France, Polytechnic University of Catalunya, Spain, Zhejiang University, Waseda University. Since March 1, 2014 he is serving as Visiting Chief Researcher, Biomedical Engineering and Robotics, at Khalifa University, Abu Dhabi, United Arab Emirates. Professor Dario is the recipient of the 1000 Thousand Foreign Talent Award (2016 – 2018) at Tianjin University, China and since 2016 he has been Principal Investigator at the Beijing Advanced Innovation Center for Intelligent Robot Systems at the Beijing Institute of Technology, China. He has been the Director of the BioRobotics Institute of Scuola Superiore Sant'Anna from 2011 to 2017. His main research interests are in the fields of medical robotics, bio-robotics, mechatronics and micro/nanoengineering, and in robotics for rehabilitation. He is the coordinator of many national and European projects, the editor of two books on robotics, and the author of 400+ journal publications (Scopus). His H-Index is 79 (Scopus), his papers have 28.400+ citations and in March 2015 he was identified by the IEEE Robotics and Automation Magazine as the second most influent scientist in robotics worldwide according to degree centrality and bibliometric criteria. He is co-author of 50+ international patents and co-founder of 5 start-up companies. Prof. Dario is an IEEE Fellow, a Fellow of the European Society on Medical and Biological Engineering, and a recipient of many honors and awards, such as the Joseph Engelberger Award and the IEEE RAS George Saridis Leadership Award in Robotics and Automation in 2014.

Daniel Goldman

Georgia Tech

Robots made of robots: soft robotics meets soft matter physics

Thursday 26
15:30 – 16:30
Conference & Meeting Centre Pancaldi Hall

I will discuss our recent work at the interface of soft robotics and soft matter physics. Soft matter, a branch of condensed matter physics, concerns systems that can be significantly deformed by energies available and on timescales relevant to humans; examples include elastomeric polymers, colloids, gels granular materials. Of course, the physics of such materials plays an important role in the components (and thus the design and control) of soft robots. However, I envision that concepts from soft matter physics like glassy dynamics, force chains, jamming, shear thickening and anomalous diffusion could more broadly play a role in design of future soft robots and robotic materials that will be composed of collectives of simple interacting robots. Inspired by our work on geometric cohesion via entanglement of u-shaped particles, we developed 3-link, 2 servo-motor robots (~10 cm long) which we call "smarticles" (smart particles) which can change shape on command and/or via environmental stimuli (like arm stresses, sound and light). To illustrate, I will discuss two examples of our efforts to discover principles by which robots and robotic materials could develop functional capabilities via mechanical interactions of smarticles: 1) Smarticle "materials": Entangled chains of smarticles can mimic solids and fluids during loading, e.g. tunable strain or strain-rate dependence with simple changes in programming. 2) Supersmarticle locomotion: In certain configurations the smarticles cannot locomote individually. However, collectively, smarticles confined by a movable ring can form a stochastically locomoting robot whose movement can be controlled by modulating the shape of a single smarticle;

the robot can display phototaxis with little programming. In summary, using smarticles and concepts from soft matter physics, we envision discovery of principles by which future "slime mold"-like soft robots can be made to quickly and flexibly change shape, material properties, and tasks.

BIOSKETCH

Dr. Daniel Goldman is the Dunn Family Professor in the School of Physics at the Georgia Institute of Technology (GT). He received his PhD in 2002 from the University of Texas at Austin, studying nonlinear dynamics and granular media. He did postdoctoral work in locomotion biomechanics at the University of California at Berkeley. Prof. Goldman became a faculty member at GT in the School of Physics in January 2007, and is core faculty of the GT Institute for Robotics and Intelligent Machines (IRIM), on the management team of the GT Soft Matter Incubator, a member of the GT Bioengineering Graduate Program, and is an adjunct member of the School of Biological Sciences. Prof. Goldman's research program investigates the interaction of biological and physical systems with complex materials. He takes a comparative approach, for example, looking for common principles in the bio and neuromechanics of sand-swimming in lizards and snakes. He has introduced the discipline of ``robophysics'' to discover principles by which self-prepelled systems perform work in the real world. His work has been featured popular outlets like the New York Times, Discover Magazine. Prof. Goldman awards include a Georgia Power Professor of Excellence, a Dunn Family Professor in the School of Physics at GT, a Fellow of the American Physical Society (2014), and has received an NSF CAREER/PECASE award, a DARPA Young Faculty Award, a Sigma Xi Young Faculty award, and a Burroughs Wellcome Fund Career Award at the Scientific Interface.

Mark Cutkosky (& inchworm climber)

Stanford University

Selectively Soft Robotics

Friday 27

9:00 – 10:00

Conference & Meeting Centre Pancaldi Hall

As robots move beyond manufacturing applications to less predictable environments, they increasingly can benefit, as animals do, from integrating sensing and control with the passive properties provided by particular combinations and arrangements of materials and mechanisms. This realization is partly responsible for the recent proliferation of soft and bioinspired robots. However, many structures and mechanisms in nature are not uniformly soft. Rather, they are selectively soft – highly compliant in certain directions, or when loaded in a certain way, but stiff or inextensible when loaded differently. Such tuned materials and mechanisms, whether in animals or robots, can provide several kinds of benefits, including energy storage and recovery, increased physical robustness, and decreased response time to sudden events. This talk will explore these interrelated concepts using examples from several bioinspired mobile robots that exploit selectively soft materials and structures when interacting with objects and surfaces in the environment.

BIOSKETCH

Mark R. Cutkosky is the Fletcher Jones Professor in the Dept. of Mechanical Engineering at Stanford University. He joined Stanford in 1985, after working in the Robotics Institute at Carnegie Mellon University and as a design engineer at ALCOA, in Pittsburgh, PA. He received his Ph.D. in Mechanical Engineering from Carnegie Mellon University in 1985. Cutkosky's research activities include robotic manipulation and tactile sensing and the design and fabrication of biologically inspired robots. He has graduated over 48 Ph.D. students and published extensively in these areas. He consults with companies on robotics and human/computer interaction devices and holds several patents on related technologies. His work has been featured in Discover Magazine, The New York Times, National Geographic, Time Magazine and other publications and has appeared on PBS NOVA, CBS Evening News, and other popular media. Cutkosky's awards include a Fulbright Faculty Chair (Italy 2002), Fletcher Jones and Charles M. Pigott Chairs at Stanford University, an NSF Presidential Young Investigator award and Times Magazine Best Innovations (2006) for the Stickybot gecko-inspired robot. He is a fellow of ASME and IEEE and a member of Sigma Xi. Cutkosky's laboratory and research can be found at http://bdml.stanford.edu.