FW3
Current and Future Related Technologies for Robotic Automation in Micro/Nano Scale

Date:
September 30, 2011
Friday, Full day

Abstract:
Robotics and automation technologies in micro-nano scale are widely investigated for various fields, for example high-precision assembly of micro-nano devices, analysis of micro-nano materials, In-vitro analysis/control of biological cells, In-situ medical surgery robotics, and so on. These technologies are important for the next-generation industrial applications and technologies by high precision control, high speed analysis, high integration, low energy consumption, low weight, and so on.

We discuss the current and future related technologies based on robotic automation in micro/nano scale. In this workshop, we share the latest results for various application fields related on robotics and automation technologies in micro-nano scale, and discuss for the future sustainable technologies in micro-nano scale.

Primary/secondary audience:
The audience includes the senior/young researchers, students, engineers, who are working on control engineering, bio-medical engineering, device construction, micro/nano industrial applications, automation engineering, sensor/actuator engineering and so on.

List of topics:
Micro-Nano Robotics Automation
Micro-Nano Manipulation Technology
Micro-Nano Bio-Manipulation
Micro-Nano Control Technology
Micro-Nano Devices based on Robotics Technology
Micro-Nano Biological/Medical Applications

Time Schedule:

09:00-09:30 Toshio Fukuda
Department of Micro-Nano Systems Engineering, Nagoya University, Japan
"Objective and Future Direction of Micro/Nano Robotic Automation System"

Current and Future Related Technologies for Robotic Automation in Nano Scale

09:30-10:00 Paul Ashby
The Material Science Division, Lawrence Berkeley National Laboratory, USA
"Encased Cantilevers and Alternative Scan Algorithms for Ultra-gentle High Speed Atomic Force Microscopy"

10:00-10:30 Coffee Break

10:30-11:00 Masahiro Nakajima
Center for Micro-Nano Mechatronics, Nagoya University, Japan
"Nano-surgery System based on Nanorobotic Manipulations"

11:00-11:30 Jeff Urban
Inorganic Nanostructures Facility, Lawrence Berkeley National Laboratory, USA
"Energy Generation and Storage in Designer Hard-soft Composite Materials"

11:30-12:00 Discussion

12:00-14:00 Lunch

Current and Future Related Technologies for Robotic Automation in Micro Scale

14:00-14:30 C. J. Kim
Mechanical and Aerospace Engineering Department, University of California, Los Angeles (UCLA), USA
"UCLA Microhand: Development and Applications"

14:30-15:00 Masaru Kojima
Department of Micro-Nano Systems Engineering, Nagoya University, Japan
"Micro-structures Driven by Bacterial Actuation"

15:00-15:30 Coffee Break

15:30-16:00 Kuniharu Takei
Department of Electrical Engineering, University of California, Berkeley, USA
“Artificial Electronic Skin based on Nanomaterial Active Matrix Circuitry”

16:00-16:30 Tomohiro Kawahara, Fumihito Arai
Department of Micro-Nano Systems Engineering, Nagoya University, Japan
"On-Chip Stimulation and Evaluation System for Aquatic-Microorganisms by Magnetically Driven Microtools”

16:30-17:00 Discussion and Closing

Speakers Information and Abstracts of Talks:

C. J. Kim
Mechanical and Aerospace Engineering Department, University of California, Los Angeles (UCLA), USA
"UCLA Microhand: Development and Applications"
Abstract:

Human hands, and many robotic tools that mimic them, can manipulate objects in a wide range of sizes and types by using fingers of a high degrees-of-freedom motion under tactile feedback control. If the objects are a few millimeters or smaller in size, however, there exists an unreasonable size disparity for successful handling; small robotic hand systems constructed by conventional manufacturing face similar problems. To dramatically miniaturize the tools to the level reasonable for objects under millimeters, a variety of advancements have been made during the last twenty years following the advent of micro electromechanical systems (MEMS). The recent years have witnessed great progress in the field of micromanipulators, including some that started to resemble human hands. After reviewing MEMS-based “microhands” inspired by the out-of-plane gripping motion of human hands, we will introduce the UCLA Microhand and its variations, which are designed for specific tasks in a range of application areas, including biomedical.

Jeff Urban
Inorganic Nanostructures Facility, Lawrence Berkeley National Laboratory, USA
"Energy Generation and Storage in Designer Hard-soft Composite Materials"
Abstract:
The interface between hard and soft condensed matter presents new and compelling research opportunities in the transport of energy and mass due to the dramatic contrasts in bonding energy, chemical interactions, and transport modalities between these constituents. Here, I will discuss my group's research efforts at designing, characterizing, and modeling the transport properties of nanocrystal-polymer hybrid systems, which I have developed as platforms for understanding the critical role that interfaces can play in dictating transport properties. Specifically, this talk will encompass two thematic areas in this space. I will first discuss energy transport in the context of thermoelectrics for Te nanorod-PEDOT:PSS polymer hybrid materials, and gas transport and storage in Mg nanocrystal:PMMA polymer hybrid materials.

Kuniharu Takei
Department of Electrical Engineering, University of California, Berkeley, USA
“Artificial Electronic Skin based on Nanomaterial Active Matrix Circuitry”
Abstract:
Macroscale flexible electronics with high performance and low cost fabrication are of great interest for human and robotic interfaces. One of the candidates to achieve these electronics is transferable “inorganic nanomaterials” due to high electron/hole mobility and mechanically flexible. In this workshop, a technique of "uniform inorganic nanomaterial patterning" on any substrates such as Si and flexible plastic is demonstrated for transistor and sensor applications on the flexible substrates with considering the design to achieve conformal covering toward three dimensional objects. Finally, as one of the applications, pressure distribution using an active matrix circuitry based on nanowire arrays and carbon nanotube networks transistors is mapped out for the application of artificial electronic skin. Notably, the device can here provide impressive mechanical robustness and electrical properties while the integration of nanomaterials and macrodevices represents an important milestone toward the realization of future wearable electronic.

Masahiro Nakajima
Center for Micro-Nano Mechatronics, Nagoya University, Japan
"Nano-surgery System based on Nanorobotic Manipulations"
Abstract:
Nano-scale biological evaluation and analysis are important to reveal unknown properties of biological cells and novel diagnosis system. We have been developed the nanomanipulation system inside Environmental-SEM to realize nano-scale manipulations under nano-meter

scale high-resolution environment. Recently, we proposed the hybrid microscope, which is combined with an optical microscope (OM) and an E-SEM. The inner structural observation and fluorescent imaging can be achieved by the OM observation.
Some applications for *Caenorhabditis elegans* (*C. elegans*) were proposed based on the nanomanipulation system. For example its viability was analyzed from the eGFP fluorescent intensity under E-SEM observation with electron beam irradiations. The nanoprobe was developed to inject fluorescent dyes (quantum dots) into the target cells inside *C. elegans* body.

Masaru Kojima
Department of Micro-Nano Systems Engineering, Nagoya University, Japan
"Micro-structures Driven by Bacterial Actuation"
Abstract:
Micro-nano robot and bio-MEMS are well studied. To realize micro-nano robot, it is necessary to construct actuator for driving. Micro-nano actuator is also needed when we make built-in mechanical factor in bio-MEMS. For constructing such kind of micro actuator, (i) mechanical and electrical factor, (ii) biological macromolecule including protein, and (iii) living organism itself are used. The biological macromolecule and living organism are worked as very small and highly effective actuator, because chemical energy is used instead of electron force. Thus, these bio-actuators are expected as next generation motivity. Therefore developing control method for such kind of reaction is important. Recently, our laboratory is working on establishment of bio actuator systems. Especially, we focus on bacterial actuation system. In this talk, we will show our recent results related on this topics, for example, micro-structures driven by bacteria and so on.

Paul Ashby
The Material Science Division, Lawrence Berkeley National Laboratory, USA
"Encased Cantilevers and Alternative Scan Algorithms for Ultra-gentle High Speed Atomic Force Microscopy"
Abstract:
Many soft materials readily deform under the minimum force required to perform an AFM measurement precluding imaging at high temporal and spatial resolution. We reduced the force noise of the cantilever by reducing the fluid viscosity with a protective encasement for the cantilever so that the cantilever is dry but the tip still probes the sample in solution. Encased cantilevers have exceptionally high resonance frequency, Q factor, and detection sensitivity and low force noise enabling gentle high speed imaging. Present raster scan techniques are poorly matched to the instrument limitations of Atomic Force Microscopy making data collection slow. We have used advanced image processing tools such as inpainting to recover high-resolution images from sparse quickly collected images to improve temporal resolution without applying more force or increasing bandwidth. We are also using spiral scanning to increase temporal resolution by allowing higher tip velocities without distortion. Inpainting or interpolation is used to quickly create images from the nongrided data.

Tomohiro Kawahara, Fumihito Arai
Department of Micro-Nano Systems Engineering, Nagoya University, Japan
"On-Chip Stimulation and Evaluation System for Aquatic-Microorganisms by Magnetically Driven Microtools"
Abstract:
In the biomedical field, mechanical stimulation to a single cell is highly required to figure out function and mechanical property of cells. Especially, in terms of neurology and bio-fuel technology, since the mechanical characteristics of a number of aquatic-microorganisms have

not been fully understood yet, mechanical approach is really important to understand the cell interaction, growth factor of cells, and function of mechanoreceptor. In this presentation, we show an on-chip robotic system to manipulate and measure aquatic-microorganisms by magnetically driven microtools (MMTs) which has a performance with the generative force of mN-order and the positioning accuracy of um-order. In order to evaluate the relationship between the mechanical stimulation and the response of the cell in a microfluidic chip, the specific design and fabrication for MMT is discussed. Furthermore, technical issues and future direction of our approach will be discussed.

Toshio Fukuda
Department of Micro-Nano Systems Engineering, Nagoya University, Japan
“Objective and Future Direction of Micro/Nano Robotic Automation System"
Abstract:
Various applications are developed in academic and industrial fields by micro-nano scale robotic manipulation and control technologies, mainly biological and medical fields. In this presentation, the objective and future direction of this field will be discussed. In our laboraty, the EndoVascular Evaluator (EVE) was developed for arterial blood vessel simulator for the evaluation and training of a catheter surgery operation. This technique was applied for a biodegradable scaffold of blood vessel for a regeneration medical application. It can be realized that the local stress analysis of aneurysm of EVE during the catheter surgery based on photo-elastic effects.
We also developed a nanorobotic manipulation system inside an environmental scanning electron microscope (ESEM). This system can be applied for a characterization of the mechanical/electrical property of single cells. For example, we presented a novel oscillating nano knife for single cell cutting. Single yeast cell cutting using oscillating nano knife was performed based on the nanorobotic manipulation system. The maximum cutting forces and the slices angle were measured from the deformation of the nano knife beam and the single cell. The result showed the oscillating nano knife was capable and effective for single cell cutting task.

Organizers:

Masahiro Nakajima
Nagoya University, Center for Micro-Nano Mechatronics
E-mail: nakajima@mein.nagoya-u.ac.jp

Toshio Fukuda
Nagoya University, Department Micro-Nano Systems Engineering
E-mail: fukuda@mein.nagoya-u.ac.jp