Nano-Robotic Manipulation Systems using Nanoprobes

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Abstract:

Handling of and interacting with smaller and smaller size objects where the human sensing, precision, and direct manipulation capabilities lack is one of the promising future trends in the robotics field. Due to the recent developments in nanotechnology, handling of materials especially at the molecular and nanometer scales has become a new challenging issue. Therefore, nano-robotics has recently emerged as a new robotics field that encompasses the design, fabrication and programming of robots with overall dimensions down to few micrometers, and the programmable manipulation of nanoscale objects

This work is focused on developing theories and methodologies of analyzing, designing, building, and controlling Atomic Force Microscope (AFM) and glass micropipette based robotic nano-manipulation systems. At first, the understanding of nanoscale physics and dynamics for reliable nano-robot design, prototyping, and control for a given AFM based nano-manipulation task is improved by modeling. As target nano-manipulation tasks, teleoperated touching to surfaces, 2D nanoparticle assembly by pushing, and drawing 3D polymer micro/nano-fibers are selected. Using nano-physical continuum models of surface forces and contact mechanics, a real-time Virtual Reality nano-simulator is developed. Next, the issue of real-time monitoring of the AFM probe tip and nano-entity positions and behavior during nano-manipulation in ambient conditions is solved by integrating AFM probe force sensing with nano-physics models by developing an Augmented Reality system. As nano-manipulation control methods, stable and robust bilateral teleoperation control techniques are investigated. Using the knowledge and models acquired, novel fully autonomous control methods are challenged. This work could enable nanotechnology products such as nanomaterial characterization workstations and 3D micro and nano-fiber drawing systems for nanoscale smart materials, adhesives, electronic and optic devices, actuators, and sensors applications.

Bio:

Metin Sitti received the BSc and MSc degrees in electrical and electronics engineering from Bogazici University, Istanbul, Turkey, in 1992 and 1994, respectively, and the PhD degree in electrical engineering from the University of Tokyo, Tokyo, Japan, in 1999. He was a research scientist and lecturer in the Department of Electrical Engineering and Computer Sciences, University of California at Berkeley during 1999-2002. He is currently an assistant professor and the director of the NanoRobotics Laboratory in Department of Mechanical Engineering and Robotics Institute at the Carnegie Mellon University. His research interests include micro/nano-robotics, micro/nanomanufacturing, biologically inspired micro/nano-systems, and biomedical miniature robots. He received the NSF CAREER award in 2005 for his nanorobotics related research and teaching activities, and the Struminger award for his teaching activities at CMU. He was invited as a speaker to the National Academy of Sciences, Keck Foundation Life Engineering Symposium in 2005, and elected as the Distinguished Lecturer of the IEEE Robotics and Automation Society for 2006-2007. He also received the best biomimetic paper award in the IEEE Robotics and Biomimetics Conference (2004), the best paper award in the IEEE/RSJ International Conference on Intelligent Robots and Systems (1998), and the best video award (2002), the best student paper nomination (2001), the best manipulation paper nomination (2004), and the best paper nomination (2000) in the IEEE Robotics and Automation Conference. He is the chair of the IEEE Nanotechnology Council, Nanorobotics and Nanomanufacturing Technical Committee and the IEEE Robotics and Automation Society, Rapid Prototyping in Robotics and Automation Technical Committee. He is an editorial board member of Journal of Micromechatronics, Journal of Nanoscale Science and Engineering, and International Journal of Control, Automation, and Systems.