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MINIATURE MOBILE ROBOTS DOWN TO MICRON SCALE

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ABSTRACT

Miniature mobile robots have the unique capability of accessing to small spaces and scales directly. Due to their small size and small scale physics and dynamics, they could be agile and portable, and could be inexpensive and in large numbers if they are mass produced. Different scale miniature robots with various locomotion capabilities are presented in this talk. These miniature robots would have applications in the fields of mobile sensor networks, environmental monitoring, health-care, inspection, space, security, entertainment, and education. First, as palm-size and centimeter scale robots, climbing robots using gecko foot-hairs inspired micro/nano-fiber adhesives as their repeatable and power efficient attachment materials are proposed. Polymer elastomer micro-fiber arrays with angled and mushroom shaped tip endings and nanoscale and molecular scale polymer fibers on top of the micro-fiber tip endings are demonstrated. These synthetic adhesives are as strong as biological gecko foot-hairs on smooth surfaces. Various climbing robot and biomedical capsule robot prototypes using these adhesives show the feasibility of fibrillar adhesives based friction and adhesion enhancement on smooth and micro/nanoscale rough surfaces. Next, going down to tens or hundreds of micron scale robots, significant challenges are on-board actuation principles and power sources. As two alternative approaches, first, external powering and actuation are used to move permanent magnet 100 micron scale robot bodies on planar surfaces in air or in liquid in 2-D. As the next approach, a hybrid (biotic/abiotic) actuation principle is used to propel micron scale robotic bodies in liquid by harvesting the flagellar propulsion of attached bacteria and the chemical energy in the environment. Randomly attached bacteria are shown to propel 10 micron diameter polystyrene beads at an average speed of 15 μm/sec stochastically. Stop-and-go propulsion control of bacteria attached beads is demonstrated using chemical stimulus where heavy metal cupper ions hinder their propulsion while ethylenediaminetetraacetic acid resumes their motion. To improve the speed and direction performance of the bacteria attached micro-robotic bodies, micro/nano-patterning methods are proposed.

BIOGRAPHY

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 in the Department of Electrical Engineering and Computer Sciences, University of California at Berkeley during 1999-2002. He is currently an associate professor in the Department of Mechanical Engineering with joint appointments in the Robotics Institute, Electrical and Computer Engineering, and Biomedical Engineering at Carnegie Mellon. He is the director of the NanoRobotics Laboratory. His research interests include miniature mobile robots, biologically inspired micro/nanosystems, and micro/nanoscale manipulation and manufacturing systems.