Extended Abstract with Poster

Bringing MEMS technology Closer to Undergraduate Education via the Mobile Microrobotics Challenge

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Abstract

The Robocup initiative has emerged as a platform for fostering robotics research by providing a set of standard problems categorized into leagues. During the first Robocup event, almost two decades ago, robots could not perform many of the required tasks; however, they have since improved dramatically in both reliability and performance. Recognizing the value of such events, the US NIST has proposed a similar robot competition at the microscale (the Mobile Microrobotics Challenge – MMC). The UT Arlington Microrobotics team has successfully competed twice in these event, with broad participation from both undergraduate and graduate students. Microrobots utilize Micro Electro Mechanical System (MEMS) technology, and are actuated using real-time control systems. As a result, the competition is an excellent vehicle for undergraduate student education, and an important introduction to engineering problems at the micro and nano scales.

Introduction

The first MMC competition was held in 2007 with the name Robocup Nanogram [1]. A dozen teams designed and fabricated micrometer scale robots that can be powered and controlled without wires. During the International Conference on Robotics and Automation (ICRA 2010, 2011, 2012), the event (Mobile Microrobotics Challenge - MMC) called for competition with untethered microrobots that must fit within a 600 μm diameter sphere [2]. On a controlled setup under a microscope, microrobots race along a distance of 2 mm, push micropegs, and insert them into holes, or they demonstrate a freely selected style of operation. In 2013, NIST delegated responsibility for the organization of the MMC to the IEEE Robotics and Automation Society, and the next challenge will be held at ICRA 2013 in Karlsruhe, Germany by a committee representing the Micro-Nano Robotics TC of IEEE-RAS [3].

At the present time, qualifying for the challenge proves to be an incredibly difficult feat, which suggests that much research in this field is needed. Many of the finalists who competed in 2010-2012 used magnetic fields to power their microrobots. At present, the competition is dominated by European teams, for instance ET Zurich using the Octomag magnetic drive, although several US teams (CMU, U. Hawaii) have also been strong contenders. All participants directly credit the MMC competition for channeling their research efforts toward demonstrable and robust microrobotic technology, as opposed to impractical lab curiosities. Popa lead a team of students from UT-Arlington to the 2011 and 2012 challenges [4-5]. Our microrobots used vibration and laser energy for power and motion control.

Approach

For the 2013 competition in Karslruhe, Germany, the UTA Microrobotics Team is sponsored by the UTA Research Institute (UTARI), and plans to participate using magnetic field-powered microrobots with increased maneuverability (Figure 1). Both graduate and undergraduate students are part of our teams, and share multiple team responsibilities including microrobot modeling, fabrication, control, and system integration. Sub-mm scratch drive robots are powered and controlled through wireless transmission of magnetic energy by a magnetic field drive system that we will bring to the competition.

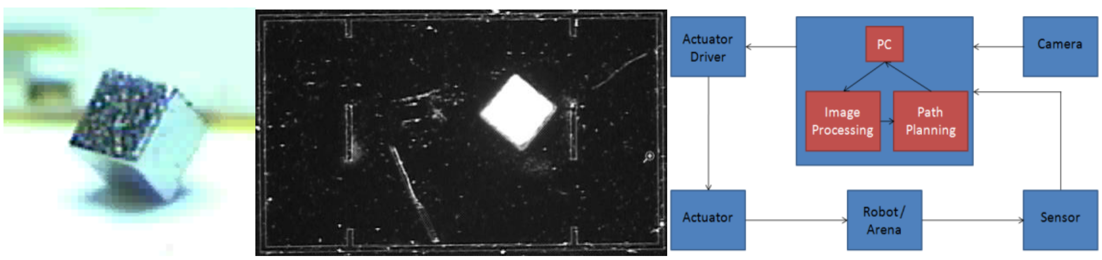

Figure 1: (Left) 3D Photo of a 500 μm cube microrobot, MAGBOT. (Center) Top view of microrobot on the 3x2 mm arena, (Right) Control system diagram.

This system consists of a computer running National Instruments Labview, robot actuators and driver from Newport Corporation, robot arena and microrobot, and a high speed FPGA camera microscope. A new operator interface for teleoperation of the microassembly task is being set up using a Microsoft Kinect®. This sensor captures the human/operator's body position, in specific the hand, which will be used to control the mobility of the microrobotic platform giving the operator a more intuitive control over the system. And the mobility challenge consists of automated microrobot motion control, without operator intervention. For this task, students must close the control loop from the microscope to the precision positioning stages to make the robot follow a figure "8" trajectory on the microrobot arena.

Conclusion

The IEEE MMC brings students in all engineering disciplines closer to the micro-nano world through an exciting type of competition, which requires both theoretical and practical know-how in microfabrication, metrology, control, and system integration. At UTA, this endeavor has been combined with Undergraduate Electrical Engineering education through independent study projects, Senior Design projects, and is an excellent bridge to follow-up micro-nanoscale instruction in graduate school. Furthermore, it presents an opportunity for engineering students to interact with sponsor companies, and engage in other outreach activities. Future papers will describe more detailed competition, including research technology and educational outcomes of MMC.

References

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Dr. Popa currently serves as an Associate Professor of Electrical Engineering at the University of Texas at Arlington. His research interests include robotics and control systems, including micro and nano robotics, assistive robotics, advanced real time control, and human-robot interaction. In addition to teaching duties in the EE department, Dr. Popa is affiliated faculty at UT Arlington's Research Institute, where he plays an active role in research and commercialization activities.

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