VISUALLY-GUIDED MULTI-PROBE MICROASSEMBLY OF SPATIAL MICROELECTROMECHANICAL SYSTEMS

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An Abstract of a Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the Degree of

DOCTOR OF PHILOSOPHY

Major Subject: MECHANICAL ENGINEERING

The original of the complete thesis is on file
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December 2011

Abstract

Visually guided multi-probe microassembly is a novel method to assemble microparts to produce micro-electromechanical system (MEMS) devices consisting of multiple microparts. Current generation MEMS devices are monolithically fabricated, and this results in an effectively planar device with limited degrees of freedom. By assembling devices it is possible to produce devices with more spatial motion.

Assembling microparts is difficult because of the scale of the objects. On the micro-scale inertia, friction, and gravity become insignificant compared to a set of adhesion forces that cause the part to stick to the manipulator. The parts tend to be fragile and stiff. Even a slight error in position or force can cause the part to be damaged or be ejected. Previous microassembly technologies have normally used microgrippers or "fingers" to manipulate the part, however they have been limited in dexterity, accuracy, robustness, or variability in graspable parts.

The developed microassembly method uses multiple sharp-tip probes together with multiple microscope cameras to grasp, manipulate, and assemble parts. Computer vision algorithms are used on the microscope camera images as feedback to counteract these effects through a compliant grasp method and closed-loop visually guided motion to correct for error. Vision force estimation is applied during manipulation to ensure the correct grasp pressure on the parts. The combination of an unstable, multi-finger, compliant grasp that has inherent uncertainty with hyper-stereo computer-vision feedback is the unique contribution of this work.

This thesis discusses the history of microassembly, the multi-probe microassembly method, part grasping, manipulation mechanics, computer vision algorithms, the Microassembly Experimental Testbed, and a new computer communication framework named Robot Raconteur. Experimental results include a fully autonomous closed-loop planar part manipulation, fully autonomous single part assembly, and semi-autonomous assembly of a 800 µm by 400 µm microstructure made up of four parts. Future work is discussed on extending the system to fully autonomous assembly of microstructures.