

Simple, Reliable Robotic Grasping for Human Environments

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Please see accompanying video at:

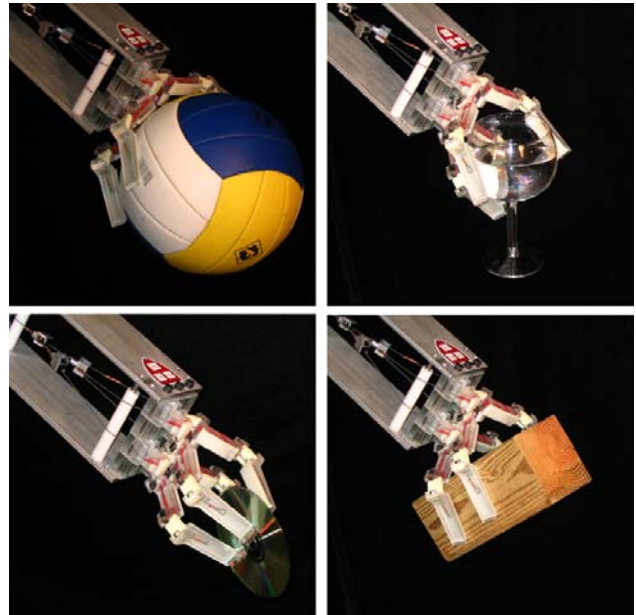
http://web.media.mit.edu/~adollar/SDM_Hand.avi

The application of robots in human environments is being hindered by the lack highly functional hands, with robots currently relegated to grasping tasks in very controlled environments such as factory floors. In order to realize the application of robots as domestic assistants, for instance, they must be able to grasp and manipulate objects in the human environment. The nature of these unstructured environments, however, where object properties are not known *a priori* and sensing is prone to error, imposes unique challenges for manipulation. The uncertainty in the relationship between the object and gripper makes it difficult to control contact forces and establish a successful grasp.

Traditional approaches to this problem involve hands that are complex, fragile, require elaborate sensor suites, and are difficult to control. Alternatively, by carefully designing the mechanical structure of the hand to appropriately incorporate features such as compliance and adaptability, the uncertainty inherent in unstructured grasping tasks can be more easily accommodated. These features can reduce the need for complicated sensing and control by passively adapting to the object properties and positioning, making the hand easier to operate, more robust, and less expensive.

In this paper, we will demonstrate a novel autonomous grasping system that is both simple and robust. The four-fingered hand is driven by a single actuator, yet can grasp objects spanning a wide range of size, shape, and mass. The hand is constructed using polymer-based Shape Deposition Manufacturing (SDM). This process uses polymeric materials to simultaneously create the rigid links and compliant joints of the gripper, with embedded sensing and actuation components. In addition to simplifying the construction process, the result is an extremely robust gripper, fully functional after impacts and other large loads due to unintended contact, and capable of grasping objects in the presence of large positioning errors.

We also will describe the results of an experimental study in which we evaluate the ability of our grasping system to autonomously grasp a number of target objects in the



Four-fingered SDM grasping a volleyball, a wine glass filled with water, a compact disc, and a large wood block.

presence of varying levels of positional error. These results will show that the hand, mounted on a three degree of freedom manipulator arm, can reliably grasp 5 cm-scale objects in the presence of positioning error of up to 100% of the object size and 10 cm-scale objects in the presence of positioning error of up to 33% of the object size, while keeping acquisition contact forces low.

*Note that this work was previously presented at the 2007 IEEE International Conference on Robotics and Automation (ICRA).

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Aaron M. Dollar received the Ph.D. degree in engineering sciences from Harvard University, Cambridge, MA, in 2006. He is currently a Postdoctoral Associate at Harvard–Massachusetts Institute of Technology (MIT) Division of Health Sciences and Technology, MIT, Cambridge. His current research interests include robot manipulation and prosthetics and rehabilitation robotics. He is a cofounder and an editor of RoboticsCourseWare.org, an open repository for robotics pedagogical materials. Dr. Dollar is the recipient of the Best Student Paper Award at the 2007 IEEE International Conference on Rehabilitation Robotics and the first prize in the 2006 American Society of Mechanical Engineers (ASME) Student Mechanism Design Competition, Graduate Division.