GraspIt!: A Versatile Dynamic Simulator for Robotic Grasping

Andrew T. Miller   Peter K. Allen
Dept. of Computer Science, Columbia University, New York, NY 10027*
http://www.cs.columbia.edu/~amiller/graspit

1 Introduction

One feature that modern robotic simulators lack is the ability to accurately model contacts and friction. However, recent work is changing that. One branch of robotics that can clearly benefit is grasping. At its core robotic grasping involves the forming and breaking of contacts between the links of a robotic hand and one or more objects in the environment. Like other simulation systems, a grasping simulator would allow a designer to prototype and test different hand designs and evaluate different control algorithms, but it can also serve as a planning environment for the larger grasping task, including reach planning, grasp selection, and object acquisition.

Working toward this goal, we have created a system, known as "GraspIt!"[1], that can accommodate arbitrary hand and robot designs–the user simply specifies the kinematics in a configuration file and provides the link geometry files. It also includes a rapid collision detection and contact determination system that allows a user to interactively manipulate the joints of the hand and create new grasps of a target object. Each grasp is evaluated with numeric quality measures, and visualization methods allow the user to see the weak point of the grasp and create arbitrary 3D projections of the 6D grasp wrench space.

The dynamics engine within GraspIt! computes the motions of a group of connected robot elements, such as an arm and a hand, under the influence of controlled motor forces, joint constraint forces, contact forces and external forces. This allows a user to dynamically simulate an entire grasping task, as well as test custom robot control algorithms.

We have also implemented an automatic grasp planner. Given a simplified model of an object constructed from shape primitives, the system can plan a set of candidate grasps, which can then be tested and evaluated. The system can account for the presence of obstacles and the reachability constraints of an attached robot arm. In practice the system can find multiple stable grasps of an object in less than 1 minute.

In the future, we will be using GraspIt! as a grasping task planner for an autonomous service robot outfitted with real-time vision and tactile feedback. We will also be exploring real-time grasping control strategies, learning algorithms for grasp planning, and dynamic deformable models.

*This work was supported in part by an ONR/DARPA MURI award ONR N00014-95-1-0601, DARPA AASERT awards DAAHO4-93-G-0245 and DAAH04-95-1-0492, and NSF grants CDA-96-25374 and IRI-93-11877.

[1]The system will soon be available for download for a variety of platforms from the web page noted above.

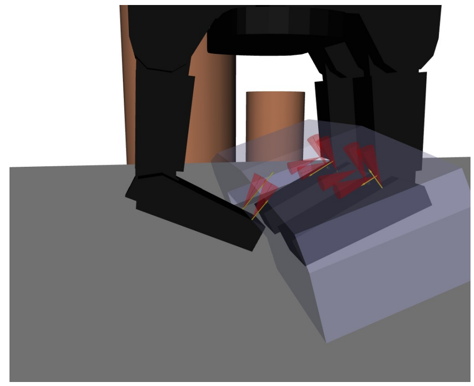

Figure 1: As the Barrett hand grasps the telephone handset, contact forces are computed and displayed to the user. Using the dynamic simulation, a researcher can test different robot control algorithms and analyze the grasp formation process.

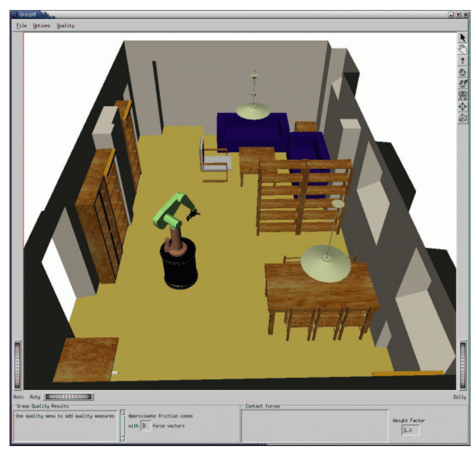

Figure 2: The system can import an entire robotic platform and a model of the world in which it operates. This allows for accurate planning of real-world grasping tasks.

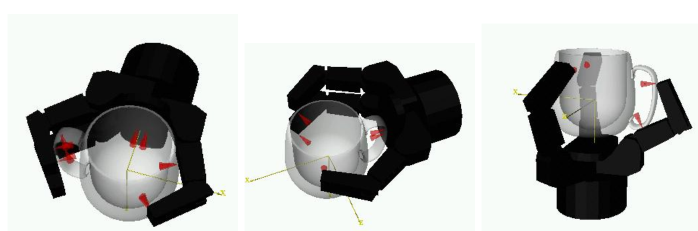

Figure 3: Three automatically planned force-closure grasps of a mug.