# AN EXPERIMENTAL TEST BED FOR ROBOTIC GRASPING

By

John H. Behmer

An Abstract of a Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE

Major Subject: COMPUTER SCIENCE



Approved:

Jeffrey C. Trinkle, Thesis Adviser

Rensselaer Polytechnic Institute
Troy, New York

April 2011
(For Graduation May 2011)

# ABSTRACT

Humans have been on earth for hundreds of thousands of years. We have evolved traits and abilities that allow us to be one of the most sophisticated species ever to live. Each and every day, we sense, touch, grasp, and manipulate with our hands. We rely on highly dexterous and capable fingers as they are so vitally important to our interaction with the environment. The human hand is extremely well-tuned to these behaviors, yet the complexity of such actions currently prohibits robotic devices from doing the same. If robots are ever to become mainstream in aiding and cooperating alongside humans, having such skills will be crucial to their success.

The field of robotic grasping is inherently multidisciplinary, spanning topics in control theory, dynamics, physics, mathematics, computer science, and even artificial intelligence. The complexity of designing a robotic system capable of grasping comes from necessity to delve into several of these major research areas. We approach the grasping problem from the ground up by constructing an experimental grasping test bed with both a robotic manipulator and a means of accurately tracking objects in the workspace. We demonstrate the effectiveness of this system not only in theory, but also on the actual hardware. Precision and repeatability are crucial to running experiments and studying their results, so all aspects of the system carefully analyzed and documented.

This thesis paper addresses many of the core issues that are crucial to studying the area of robotic grasping. We begin by developing a control system for a robotic arm and hand using software that allows for rapid prototyping in a research setting. We discuss methods for dynamic disturbance rejection and then implement both joint space and Cartesian space PID controllers, touching on the concept of impedance control. Next we explore infrared marker and rigid body tracking, and introduce a very precise method for coordinate frame transformations and alignment. We aggregate all control and tracking data into single, well-defined experiments that can be stored and retrieved from a Grasp Acquisition Database. This database can later be used to teach, replay, or study the effectiveness of particular robotic grasps.