Development of a Simulation Environment for Human/Machine Collaboration Research

Computer Integrated Surgery II
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Introduction

- I worked on using ROS/Gazebo to simulate a pair of WAM arms for research in human/machine collaboration tasks.
- This is a part of broader research into learning from demonstration approaches such as inverse optimal control (IOC) and how to adapt these approaches to the real world.
- The system can be used to work on and explore concepts related to human machine collaboration, with the eventual goal being automatic assistance of users performing complex teleoperation tasks such as robotic minimally invasive surgery.

The Problem

- Systems like the Da Vinci have multiple arms and more capabilities than a single human user can take full advantage of; we want to apply learning from demonstration to improve their ability to perform tasks.
- Current approaches for perceptually-based learning from demonstration are not used in practice
- A large problem with developing these systems is integrating vision; by working in simulation we can alleviate this issue during development.

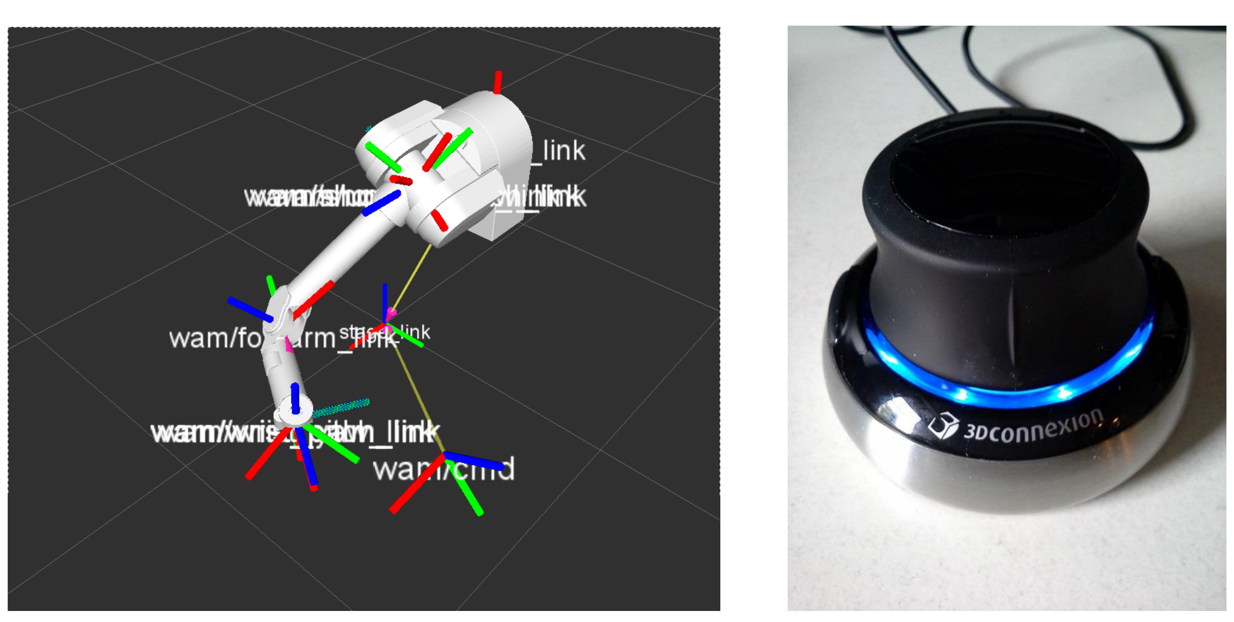

Figure 1: Control of simulated arm. Left: coordinate frames for arm components. Right: 3DConnexion Space Navigator mouse used to control the end point of the robotic arm.

The Solution

- Apply to automation of a simple peg transfer task: pick up a ring from one peg and place it on a second peg that the first arm cannot reach.
- Built off of existing code by Jon Bohren, using the ROS and Gazebo physics simulation.
- An existing simulation of the WAM arms was modified to have two separate arms operated by an inverse kinematics controller.
- User can control both arms using a simple control scheme, opening and closing one arm

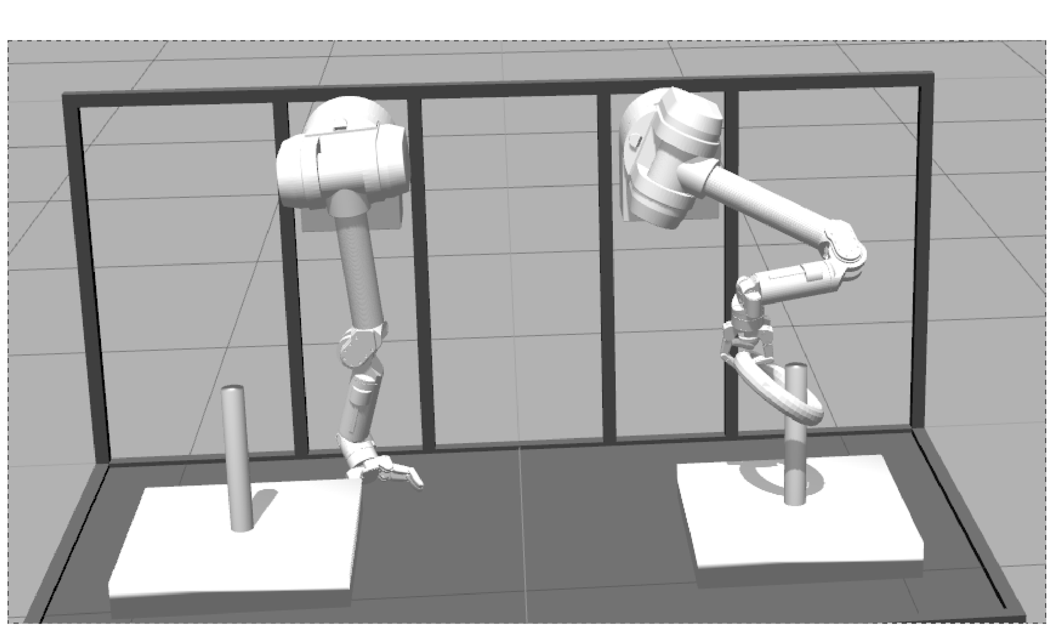

Figure 2: Picking up a ring. The WAM arms can interact with the environment, and objects behave as they would in a real-world test.

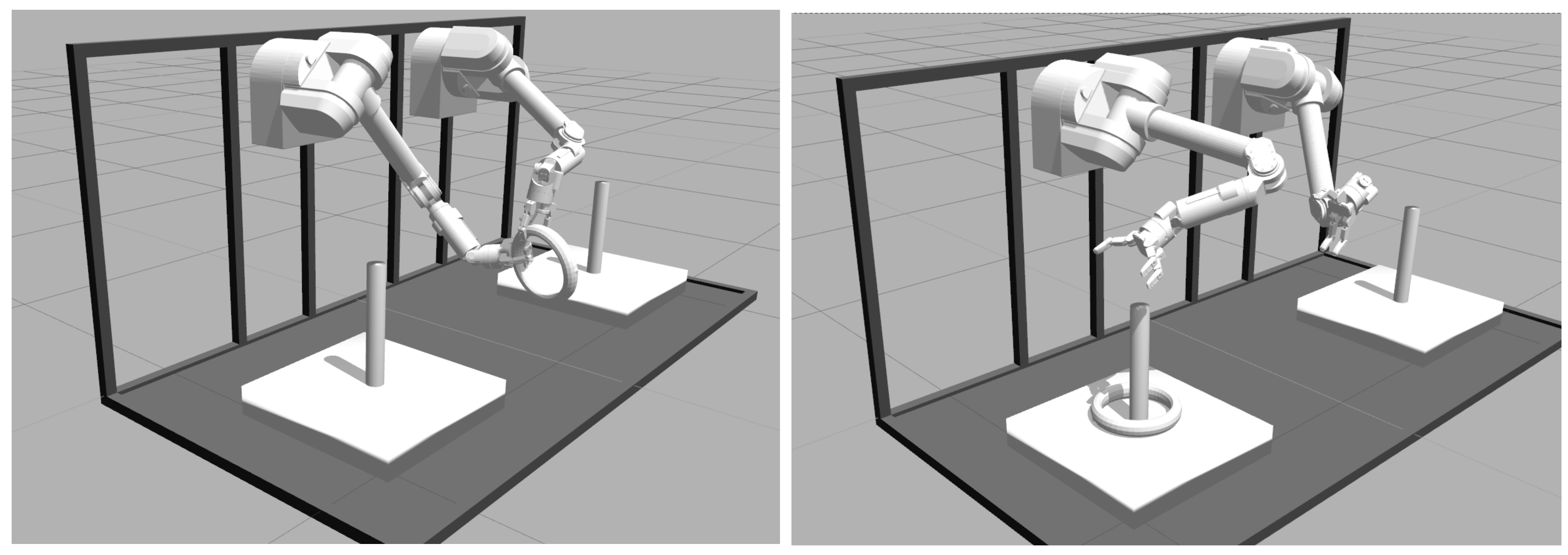

Figure 3: Simulated peg transfer task. The WAM arms cannot complete this task individually.

Outcomes and Results

- System can record and replay user trajectories, as well as record the interactions between different objects in the environment and the relative positions of different objects.
- Additional test environments created for construction of simple structures with magnetic blocks and testing trajectory adjustment to arbitrary moveable environment features.
- Performed simple test based on feature positions: applied an affine transformation between example and test environments.

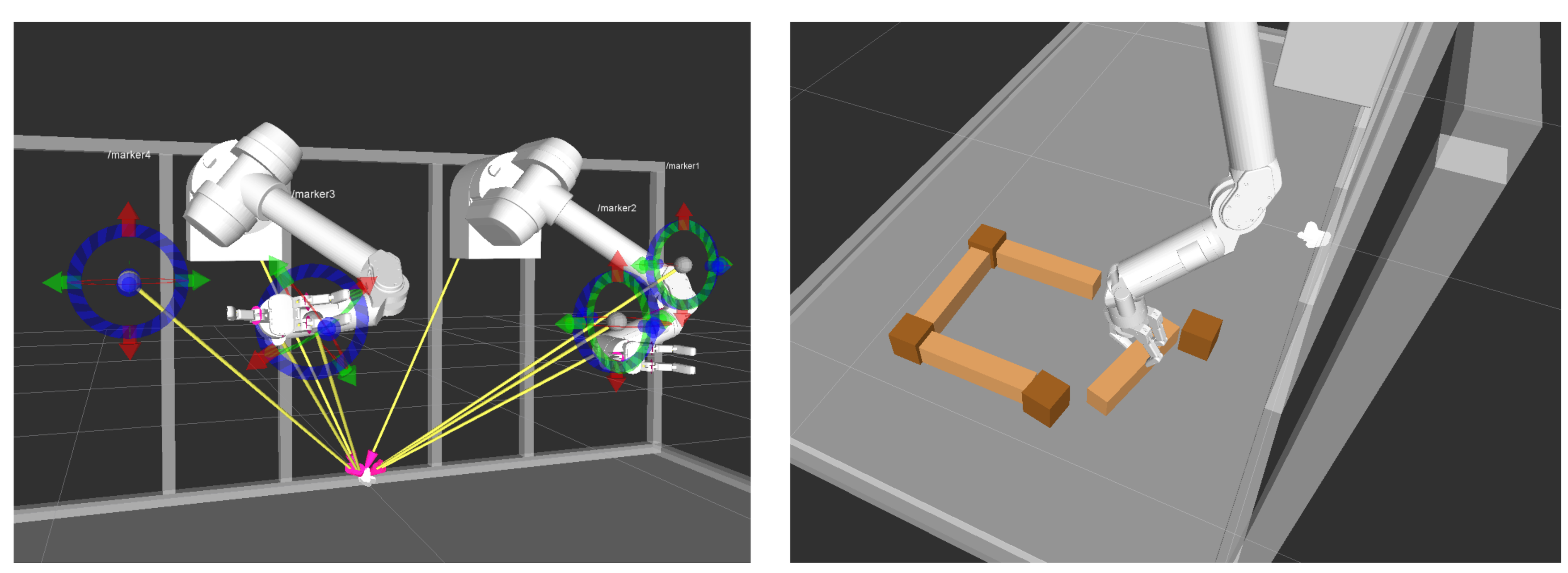

Figure 4: Additional manipulation tasks. Left: arbitrary features can be moved around between trials in the ROS RVIZ user interface for rapidly testing different trajectories. Right: construction example containing different blocks that latch together and can be taken apart.

Future Work

- Work on integrating automation through inverse optimal control with the simulated system will continue over the summer.
- Next step is to finish robust partial automation of the peg task.
- Other specific planned improvements include improving the simulation of construction tasks and integration with MATLAB for trajectory visualization and learning.

Lessons Learned

- Integration of open source software technologies such as ROS, Gazebo, and OpenCV.
- Using the ROS framework to create practical, modular robotics code; controllers in the ROS/Orocos RTT integration packages for operating the WAM arms.
- Extensive research into techniques for learning from demonstration that may be applicable to this task.

Acknowledgements

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