Proposal to Earn Credit for Research

What follows is my proposal to earn academic credit through the course CPSC 290: Directed Research for the research on artificial intelligence I will be conducting this semester (Fall 2019) in the Yale Social Robotics Laboratory. I will be continuing my work on the same project I worked on last semester, dubbed the “Crowbot.”

Project Description

We’ve set out to create a robot that is able to learn how to build and use tools, inspired by the abilities of the New Caledonian Crow (NCC, Corvus moneduloides). The NCC is able to:

- Utilize tools in situ
- Select the appropriate sized tools for completing a task without trial-and-error learning
- Spontaneously use tools to acquire more appropriate tools
- Reason about causal properties of objects and the environment
- Reshape a tool, e.g., fashion a hook from a straight tool

Recreating these learning and reasoning abilities requires programming a robot that can solve spatial manipulation problems using causal reasoning. Our approach to developing this capacity for causal reasoning artificially is to combine methods of statistical and symbolic machine learning.
Basic Expectations

• Commit 10 hrs/week to programming the robot
• Weekly meetings with advisor, Meiying Qin
• Weekly meetings with general staff of ScazLab

Current Status

As of now, the robot is able to pick up a tool and discern its pose (position and orientation) based on the marker on it. It can then learn how to use the tool if given several points on the correct trajectory (e.g., if told how to position a screwdriver over a screw). Once this skill is learned, the robot is able to reapply the tool to any object, in any position or orientation, in the task space. Even if the tool is bent from the pose where its use was initially learned, the robot is able to recognize it as the same tool and apply what it learned previously to the current task.

Next Steps/Deliverables

This semester I have been issued two principal tasks:

1. Switching to another robot

For the first half of the semester, I will be working on transferring all of the robot’s current reasoning capabilities from Baxter to either UR5 or Kuka. Completing this task will require familiarizing myself with the following software:

• ROS (Robot Operating System, a robotics middleware)
• the APIs of Baxter and the new robot
• the machine vision system

It will also require that I learn a great deal about robot kinematics.

2. Adding More Causal Reasoning Capabilities

For the second half of the semester, I will add more reasoning abilities to the robot. Currently, the robot can learn how to use a tool and reapply this skill. I will program it to be able to:

• Learn several usages for the same tool
• Be able to discern which usage for the tool is the most helpful for a task
• Learn how to re-grasp the tool to switch from one usage to another

The primary method I will use will be SML (statistical machine learning) in order to program the robot to be able to generalize perceived if-then relationships to physical heuristics approximating laws.