15-400 Project Proposal: Using Gaze to Predict User Intent
15-300, Fall 2016

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1 Project Web Page

http://apadweka-15400.weebly.com/
Location of my website may move to andrew file system next semester.

2 Project Description

For this project, I plan on working in the Personal Robotics Lab with ADA (Adaptive Dextrous Arm). I will be working with Professor Siddhartha Srinivasa and his students Henny Admoni and Shervin Javdani. Admoni, a postdoctoral fellow, will oversee, while Javdani, a PhD student, will assist me with the machine learning components. ADA is a wheelchair mounted robotic arm, which is a modified lab version of a product sold on the market.

This project intends to improve the functionality of teleoperated robotic assistance. The potential use cases of this enhancement are broad ranging from bomb disposal to the larger case of people with disabilities. Technology on the market has increasing functionality. However, users have constant and limited degrees of freedom. For example, on one extreme, we have quadriplegics with only one degree of freedom, what they express through their mouths. No matter how complicated the device they operate (and devices are increasingly complicated), they can only control the device through a simple binary sip-and-puff mechanism.

The current solution to having users with limited degrees of freedom operate devices with more degrees of freedom is changing modes for each type of action. Each mode adds an additional degree of freedom. For example, ADA is controlled by a simple joystick, but has 6 distinct joints. Switching of modes makes these devices difficult to use and the user has to be relatively precise within each of these modes to achieve their intended outcome. With ADA, for example, users have to switch mode for each individual joint in little increments instead of continuously operating the device to the end goal.

Our approach is an auto-correct of sorts built on top of the mode solution and eventually replacing it. We predict user intention and then have the robot perform the task. In this particular application, we use the joystick and user gaze together to control the robot. The idea behind this technique comes from research that shows that people look at objects they are about to interact with right before they grasp them.

My project, specifically, will be using the joystick and gaze data in order to model a user's goal. The theoretical framework I will be working within is a POMDP (Partially Observable Markov Decision Process), where the goals are hidden and the input data is a probability distribution. Challenges will occur around user behavior that changes as familiarity with the device increases and mapping gaze to the object of the gaze.

3 Project Goals

75% Goal
I would be able to generate a rough prediction of a user's intention using the gaze detection and joystick output. The model would be accurate with clearly distinct and spaced out objects.

100% Goal
Accurate prediction of any user's goals after a few uses. The model would be accurate with more obscure objects and objects that are closer together.

125% Goal
My models would be adaptable to changing usage patterns as the user becomes more comfortable with the system and uses the joystick less and less. This would correspond to a gradual transition to dependence on gaze direction and away from joystick control.

4 Milestones

4.1 1st Milestone

I plan to understand the joystick and gaze software to the point that I have a rough idea of what code I will need to write. I will start the process of ingesting and processing the data. In addition, I will read related papers from the lab. To broaden my background Machine Learning knowledge, I will also understand partially observable Markov decision processes through further reading and work with Javdani.

4.2 Bi-Weekly Milestones

January 30th
Data ingestion pipeline completed. User data will be processed through a python service and outputted in a usable format.

February 13th
First attempt at predicting user intention (predict object the user is attempting to pickup) complete building off of previous milestone's pipeline.
February 27th
Test first attempt on held out data set for accuracy of predictions, identify issues, and investigate possible fixes.
March 20th
Implement revisions and iterate code models further based off of accuracy.
April 3rd
Final, improved version, code complete.
May 1st
Final report written.

5 Literature Search

I have read two related papers from the Personal Robotics Lab. One of them covers the general idea of increasing autonomy through use of POMDPs[3] and the other suggests the use of gaze to enhance a robotic arm[1]. I will additionally need to read about POMDPs (there are plenty of online tutorials), related work in the lab[4], and external related progress[2].

6 Resources Needed

Most of the resources needed will be provided by the Personal Robotics Lab. Many, like the robot and the gaze detection headset, will only be available in the lab itself. The software needed is all available on the Personal Robotics Lab's Github. I will get the OpenRave repository and Ada package set up over Thanksgiving break. Additionally, I will depend on another project mapping the headset's gaze detection to the object of the user's gaze. Their work is happening concurrently and will only be available in the spring.

References

[1] Henny Admoni and Siddhartha Srinivasa. Predicting user intent through eye gaze for shared autonomy. In *Proceeding of the Shared Autonomy in Research and Practice*, November 2016.

[2] Eric Demeester and Alexander Huntemann. Detecting user interaction changes using the kullback-leibler distance. In *Proceeding of the Shared Autonomy in Research and Practice*, November 2016.

[3] Shervin Javdani, Siddhartha Srinivasa, and J. Andrew (Drew) Bagnell. Shared autonomy via hindsight optimization. In *Proceedings of Robotics: Science and Systems*, July 2015.

[4] Stefania Pellegrinelli, Henny Admoni , Shervin Javdani, and Siddhartha Srinivasa. Human-robot shared workspace collaboration via hindsight optimization. In *IEEE/RSJ International Conference on Intelligent Robots and Systems*, October 2016.