1 Overview

Project Summary

Clamps and "helping hands" are critical tools for skilled, dextrous work. They hold working items like circuit boards steady in a useful position. This seems like an obvious task for a robot - more flexible and user friendly than a purely mechanical solution, but stronger and more tireless than a human assistant. However, the task - holding items to aid dextrous work - has two components which often contradict one another: the grip needs to hold the object rigidly, but also compliant when necessary. At the same time, it is constrained to avoid certain areas that may be delicate, or in the way of the human. This project will tackle the problem of robotic gripping under constraints.

The goal of this project is to create a robotic system that:

- Perceives an item to be held

- Accepts human commands to grasp, let go, etc.

- Grasps that item while attempting to maintain the item's pose

- Grasps the item while obeying constraints

- Exhibits compliant behavior that allows the human to re-position the item

- Exhibits rigid behavior to keep the item steady during work

Perception Component

This component of the system collect and analyze visual input from the workspace.

Inputs RGBD data from one or more kinect sensors mounted above the workspace. Human inputs filtered through the human interaction module.

Outputs A conservative convex hull of the human arm. An estimate on the object's pose. The position of the human finger and where it's pointing. A list of suggested grips, rated by quality.

Challenges The problems that perception will tackle:

- Identifying the target object

- Distinguishing the human hand (so the robot avoids it)

- Distinguishing the item's pose in 6-dof (so the robot can attempt to match it)

- Identifying and evaluating a potential grip candidates

- Identifying the human finger and where it is pointing and incorporating that into grip ratings

- Identifying areas to avoid

2   Research Contribution

The research contribution goal will be to outline methods of perceiving grasp constraints and evaluating potential grasps under those constraints.

3   Approach

The perception module will start with the basic tasks of identifying the object and the human, identifying potential grips based using machine learning with cubes of voxels as features . The next level will add constraints on the grips - clearly marking the areas on the board that are "better" and "worse" with painted tape. The two stretch goals will be to guess for where the human is pointing and actually learn to identify fragile features, incorporating them into grip selection.

Possible Addition Integrating human feedback could be an additional novel part of the project. It's often clear to us which grip is good and strong and which one is terrible. Commands like "too loose" could reset the estimation of the grasp and, going even further, commands like "shift up a little" could modify the seed for the estimator.

3.1   Actual tasks

1. Write out the structure of the neural network for the learning algorithm

2. Create an image library of rgbd views of items with marks held by a human hand

3. Find the bounding box for the human hand/arm in the images

4. Estimate the pose of the item in the image (take 3 surface features, track them and create body axes with them to define a pose)

5. Divide images into features

6. Do offline testing to assign weights to features

7. Idenfiy vector associated with human finger and incorporate into grip selection

8. Learn to identify "bad" areas of the surface based first on markers and then on raw RGBD data

References

[1] Brenna D. Argall and Aude G. Billard. A survey of Tactile HumanRobot Interactions. *Robotics and Autonomous Systems*, 58(10):1159–1176, October 2010.

[2] Yasemin Bekiroglu, Janne Laaksonen, Jimmy Alison Jø rgensen, Ville Kyrki, and Danica Kragic. Assessing Grasp Stability Based on Learning and Haptic Data. 27(3):616–629, 2011.

[3] Dmitry; Berenson and Siddhartha Srinivasa. The Robotic Busboy: Steps Towards Developing a Mobile Robotic Home Assistant.

[4] Jeannette Bohg, Antonio Morales, Tamim Asfour, and Danica Kragic. Data-Driven Grasp Synthesis—A Survey. 30(2):289–309, 2013.

[5] Ian Lenz, Honglak Lee, and Ashutosh Saxena. Deep Learning for Detecting Robotic Grasps. January 2013.

[6] Stephen Moseson and Ashutosh Saxena. Efficient grasping from RGBD images: Learning using a new rectangle representation. *2011 IEEE International Conference on Robotics and Automation*, pages 3304–3311, May 2011.

[7] Mario Prats, Pedro J. Sanz, and Angel P. del Pobil. Vision-tactile-force integration and robot physical interaction. *2009 IEEE International Conference on Robotics and Automation*, pages 3975–3980, May 2009.

[8] Ashutosh Saxena, Justin Driemeyer, Justin Kearns, and Andrew Y Ng. Robotic Grasping of Novel Objects.