Robot Hand for Grasping Tightly Packed Objects

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Abstract

We take the ability to effectively move items around for granted, but by developing robotic limbs and computer algorithms to manipulate objects, we can give people with physical disabilities the opportunity to gain back what they have lost or never had. When most think of robot limbs, they think of claw-like applications, but these tools are not well suited to grasping objects that are tightly packed between other objects.

To solve this problem, we have developed a new robotic hand and integrated it into the Baxter research robot system. Using both a claw and a suction mount, this gripper enables grasping of a plethora of previously inaccessible objects .

To determine the effectiveness of our new design, we tested our new hand against a more traditional gripper in various real-world grasping scenarios.



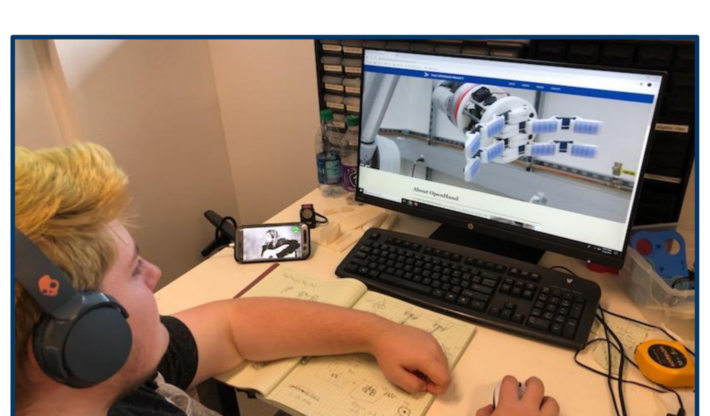
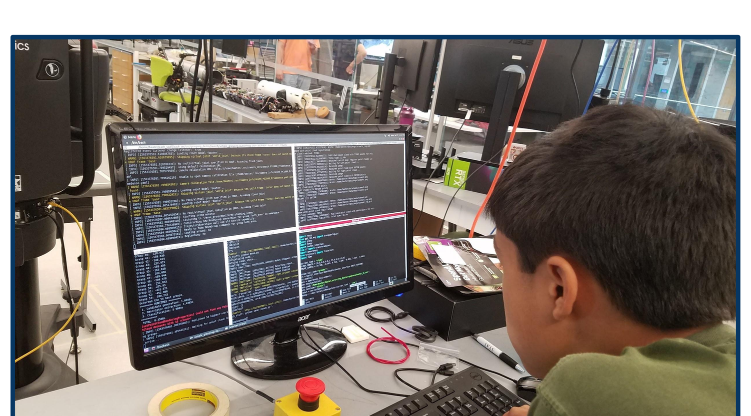
Background Research

To design and construct the gripper, we needed to become familiar with the following applications:

- Solidworks 3D Modeling Application
- Printing Software for uPrint Plus 3D Printer
- Yale's 3D Printed Robot Hands
- Amazon's Picking Challenge MIT-Princeton Robot Designs

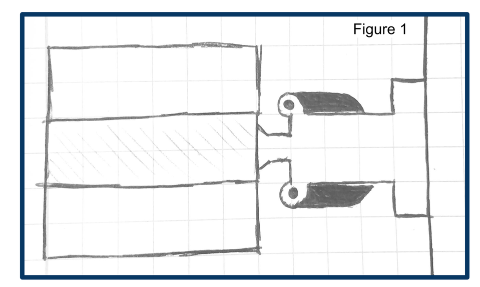
To program the Baxter robot to autonomously grasp objects with our gripper, we needed to utilize the following tools:

- Baxter Robot Operations
- OpenRAVE, robot movement simulator
- IKFast Inverse Kinematics Solver, converts from cartesian coordinates to arm joint positions
- Grasp Pose Detection Software (GPD)
- Trajectory Planning Software

Brainstorming/Design Process

At a fundamental level, our goal was to expand the versatility of our lab's traditional gripper. Having considered the capabilities it lacked with reference to a human hand, we decided to develop a pneumatic suction mount on the hand to allow it to grasp tightly packed objects. We maintained the claw-like grasp for more traditional applications, and increased the rotational range of the fingers to allow simple and efficient switching between the suction mount and the claw. We then designed the hand model and developed an algorithm to autonomously choose between employing the suction tool and the claw.



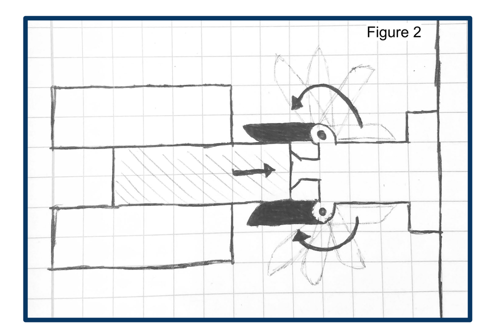


Figure 1 & 2: Grasp tactic for tightly packed objects. The claw first retracts to allow the suction mount to access the selected object. Once the object has been pulled away by the suction mount, the claw closes to establish a more secure grasp. Each application may also be used separately depending on the task.

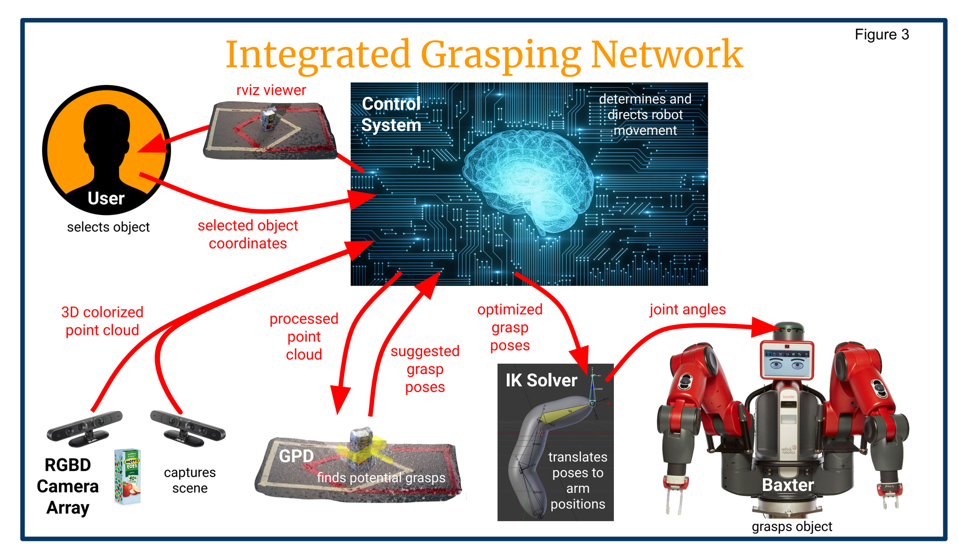


Figure 3: Integrated control system and nodal network for grasp determination and execution. After selecting an object on the graphical user interface, the user must wait only a few seconds for Baxter to perform the grasp.

Creation

3D Printed Robotic Gripper

1. Developed 3D models in Solidworks
2. Sent files to the uPrint Plus printer
3. Soaked printed pieces in acid bath to melt support material
4. Air-dried printed pieces
5. Constructed hand
6. Added pneumatic components

Autonomous Grasp Choice and Control

1. Tailored IKFast for Baxter robot
2. Adjusted GPD parameters to optimize computation time and success rate
3. Designed filtered pipe to send best GPD-suggested grasp poses to IK solver
4. Developed user interface to allow user to click objects to direct Baxter
5. Compiled system into single process that finds grasp and picks up item

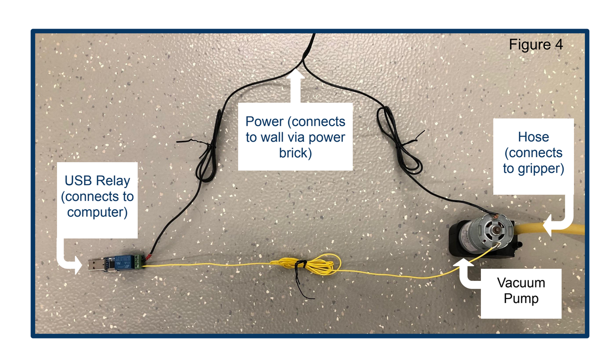


Figure 4: Electronic and pneumatic components for gripper suction mount. Vacuum pump is wired to wall power through 12 Volt 1 Amp power brick. Computer sends signal (on/off) via USB relay, opening and closing the circuit.

Final Product

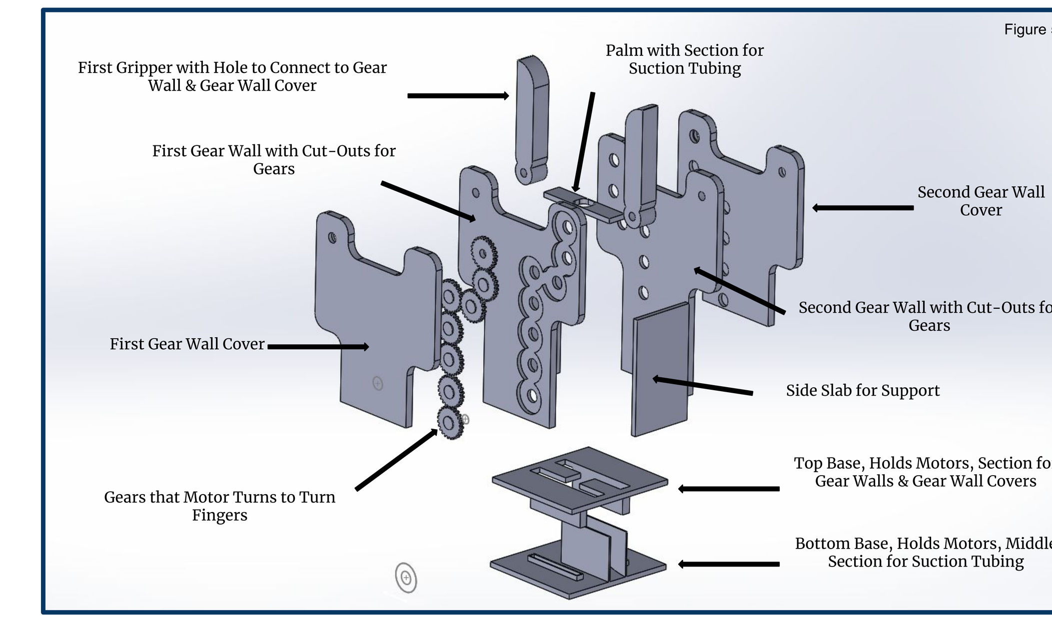


Figure 5 (above): 3D exploded model of claw portion of robotic gripper. Suction line is inserted through the inside of the gripper body. Pump mechanism mounted on robot body. Pneumatic components not shown.

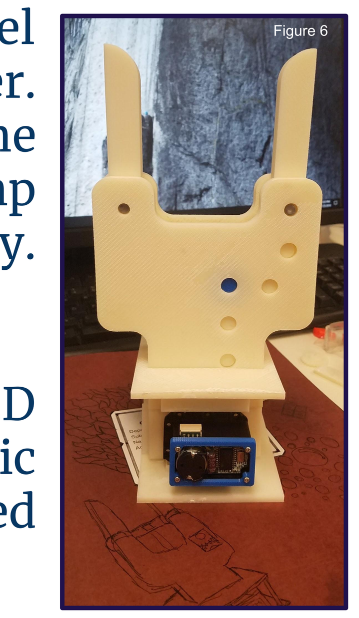
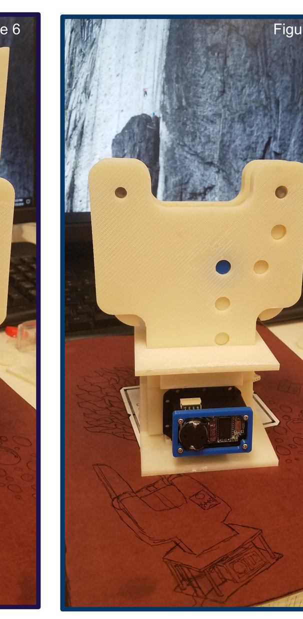



Figure 6 & 7 (right): First build of 3D printed model without pneumatic components. Claw fingers extended in figure 6 and retracted in figure 7.

Testing/Conclusion

Please see computer screen below for test results and videos.

Future Work

In the future, we hope that our new gripper will be developed further to better accommodate those with physical impairments. In addition, we hope that the lab will expand upon our gripper by upgrading our manually defined heuristics to a machine learning algorithm that can make it easier to find suction points, similar to the GPD neural network used for traditional claw grasps. We hope that the lab will follow our footsteps in expanding the versatility of their system, perhaps by enabling grasping of fragile objects.

References

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- For image citations please see computer screen below

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