A Shape-sorting Challenge: Analysis and Comparison Between the Capabilities of the Human Hand and a Simple Two-fingered Manipulator

Mechanics of Manipulation Final Project

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The World of Manipulation

• Human hand is the most complex and efficient manipulator available to us
• It hasn't been very easy to replicate the model in terms of working capabilities
• Although, if we try to restrict the task domain then one can possibly try to achieve similar results with simpler manipulators
• That is exactly the reason why we see different kind of simple grippers deployed in the industry which are made specifically for a certain task execution
What do we want to do?

• To test this belief
• To see how well a gripper performs when pitted against constrained hand manipulation in a task-specific match
• To observe the differences
• To try and reason for them
• Try to characterize what we have observed
The Definitions We Follow

• “(The) capability of changing the position and orientation of the manipulated object from a given reference configuration to a different one, arbitrarily chosen within the hand workspace,” Bicchi

• “(The) process of manipulating an object from one grasp configuration to another,” Li et al.

• “(When) multiple manipulators, or fingers, cooperate to grasp and manipulate objects,” Okamura et al

• (The) kinematic extent over which a manipulator can reach all orientations,” Klein and Blaho

• “Skill in use of hands” Sturges
Introduction to the Experiment

- The task that we have chosen for the gripper and constrained hand to match for is:

A Game of SHAPE-SORTING
Different Manipulators We Look At

A Parallel Two-fingered Gripper

Opposable Two-fingered Hand Manipulator

Parallel Two-fingered Hand Manipulator
Subjects Of The Experiment

• We observed two experienced subjects and two novices
• Here we present a concise summary of our observations
Some Statistics

### TABLE I

**Total time taken (in minutes) to complete the task of placing all the shapes in their respective slots**

<table>
<thead>
<tr>
<th></th>
<th>Parallel Gripper</th>
<th>Oppposable Fingers</th>
<th>Parallel Fingers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject 1</td>
<td>11:12</td>
<td>1:22</td>
<td>2:02</td>
</tr>
<tr>
<td>Subject 2</td>
<td>8:15</td>
<td>2:07</td>
<td>2:15</td>
</tr>
<tr>
<td>Subject 3</td>
<td>4:43</td>
<td>1:07</td>
<td>1:42</td>
</tr>
<tr>
<td>Subject 4</td>
<td>3:29</td>
<td>0:54</td>
<td>1:22</td>
</tr>
</tbody>
</table>
Observations: The Gripper

• In general, the gripper took a considerable amount time to complete the task
• The failure rate was high, with a large number of re-attempts
• Comparatively, it took more time to push the blocks inside from the lateral sides as compared to the top face
• Rather than follow the path that human hand would have chosen to complete this the task was sub-divided in smaller parts to try and increase the efficiency with the gripper
• Comparatively required more force to successfully grasp the objects
• Execution relied on both arm maneuvers to overcome simplicity of the gripper and stability of the grip from the gripper while maneuvering
Observations: The Opposable Manipulator

• Provides a lot more degrees of freedom for the subject to exploit
• Took much lesser time than gripper to complete the task
• Relied more on the dexterity of the fingers than on the arm maneuvers to complete the task
• Required least amount of force
• Restricted in-hand manipulation without the use of external surface
Observations: The Parallel Manipulator

- Required more force than the opposable manipulator to complete the task
- Allows exploitation of more degrees of freedom than the simple gripper
Some More Statistics

**TABLE II**

<table>
<thead>
<tr>
<th></th>
<th>Star</th>
<th>Diamond</th>
<th>Parallelogram</th>
<th>Clove</th>
<th>Cube</th>
<th>Cuboid</th>
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<table>
<thead>
<tr>
<th></th>
<th>Hexagon</th>
<th>Octagon</th>
<th>Pentagon</th>
<th>Oval</th>
<th>Trapezium</th>
<th>Triangle</th>
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<tbody>
<tr>
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<td>5.28</td>
</tr>
</tbody>
</table>
Characterization

• Gripper
Characterization

• Two-fingered Hand Manipulators
Interesting Observations

• Parallel manipulator and the gripper: Trapezium and Triangle
• Opposable configuration gives the subjects a lot of freedom
• The finger slide: Common to all
• The very helpful gripper flaps
Epilogue

• Task not really gripper favorable
• More of a precision task
• Non-comparable sizes of the blocks and the gripper
• However, gave us sufficient insight
THANK YOU!