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Designing A Low Cost Prosthetic Arm Device

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Designing Low-Cost Prosthetic Arm

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Abstract
The goal of the project was to build a functional low-cost, trans-radial prosthetic arm that is easily maintained. The first task was to determine the ratio of length needed between the terminal end and the arm brace. This ratio matches the Golden ratio of 1.68 because it is biologically motivated. The second task was to determine the maximum amount of force that could be used to grip objects without causing damage. A larger surface area on the gripper will allow more pressure to be used to hold an object without causing damage. The third task was to use law of Levers to choose the best fulcrum placement to reduce grip pressure. The significance of the project is to develop an effective low-cost, easily maintained prosthetic arm that could benefit people with disabilities in developing nations and who are living below the poverty line and using in MESA competition.

Materials and methods
To begin the design, a mechanical finger was built with wooden tongue depressors as bone material, rubber bands, string, and drinking straws as muscle material, and masking tape as ligament and tendon material. The length of each joint was set to the golden ratio. Using this method, a basic “hand” was created that could be used to grip objects.

The second step was to determine the amount of surface area needed to impart appropriate pressure for gripping objects without causing damage. This was measured using an olive as a model. The olive was placed on a digital scale. Three probes with differing surface areas were used to puncture the skin of the olive. The force applied to the olive at the time of puncture was noted. Three measurements were taken with each probe and average was mentioned in table 1.

The third step was use the maximum force needed to pick up the heaviest object along with law of Levers to determine the optimum fulcrum length for our prosthetic arm design.

Results

<table>
<thead>
<tr>
<th>Number</th>
<th>Measurement</th>
<th>Length mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fingertip to knuckle1</td>
<td>23</td>
</tr>
<tr>
<td>2</td>
<td>knuckle1 to knuckle2</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>knuckle2 to knuckle3</td>
<td>28</td>
</tr>
<tr>
<td>4</td>
<td>knuckle to wrist</td>
<td>62</td>
</tr>
</tbody>
</table>

Table 1: measurement the length of each joint of hand

<table>
<thead>
<tr>
<th>Number</th>
<th>Ratio Measured</th>
<th>Ideal Ratio</th>
<th>Device Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.23</td>
<td>5.18 x 10^6</td>
<td>1.02 x 10^6</td>
</tr>
<tr>
<td>2</td>
<td>3.6</td>
<td>12.6 x 10^6</td>
<td>0.28 x 10^6</td>
</tr>
<tr>
<td>3</td>
<td>5.89</td>
<td>13.4 x 10^6</td>
<td>29.80 x 10^6</td>
</tr>
<tr>
<td>Design</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Finding Golden Ratio in hand and using in designing of device

The hypothesis of design is using Golden ratio for fingertip to wrist and wrist to elbow ratio in the design.

<table>
<thead>
<tr>
<th>Probe Number</th>
<th>TIP</th>
<th>RADIUS</th>
<th>DEPTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>44.75×10^6</td>
<td>4500</td>
</tr>
</tbody>
</table>

Table 3: Force vs Area

The hypothesis is that with the area of 46.75 x 10^6 the device is able to hold all the objects without damaging them.

Conclusions
The low-cost with the weight of less than three kilogram prosthetic arm able to pickup 0.2Kg objects with different shapes, sizes and positions to maintain easily was designed with the ratio of 1.43 ~ 1.68 near to Golden Ratio for the ratio between terminal and forearm parts. The terminal with the maximum force for holding the object with weight of 2Kg was divided to two distances of d1=0.1 m and d2=0.2m. The force required to pick up the object is 39.2N and comes from moving the arm back and forward.

References

Acknowledgments
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