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Designing A Low Cost Prosthetic Arm Device

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Designing Low-Cost Prosthetic Arm

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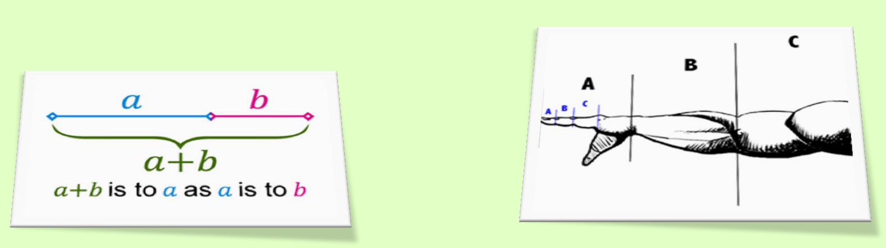
Abstract

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 refine 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.

Introductions

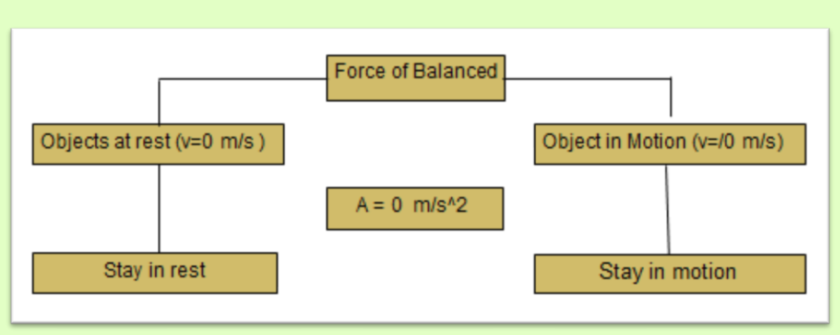
Three tasks were used to develop an effective low-cost,easily maintained prosthetic arm. The first tasks were to examine the ratio of the fingers length to the hand length.As well as the ratio of hand to the lower arm.The ratio is approximately 1.68 this also known as the Golden Ratio. This ratio appears many times in geometry,art,architecture and human body.



Picture1:Golden Ratio

$$\frac{a}{b} = \frac{a+b}{a} = 1.68$$

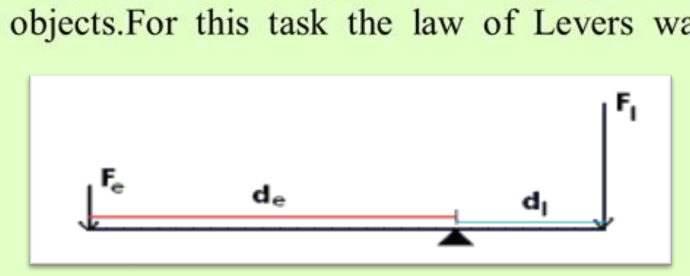
The second task was to determine the force that is needed to hold and grab the objects without causing damage to them. The weight of the heavy object to pickup was measured and this weight was used as the maximum force to find the minimum area needed to grasp an object without damaging it. The relation between the weight and the area came with Newton's first law.



Picture2:Newton's First Law- F=Ma and F=PA

F=force (N), M=mass(Kg), a=Acceleration(m/s²), P=pressure (Pa), A=area(m²)

The third task was to understand how to apply appropriate pressure that was measured in the last one and find the fulcrum placement for appropriate to grip pressure on multiple objects.For this task the law of Levers was used.

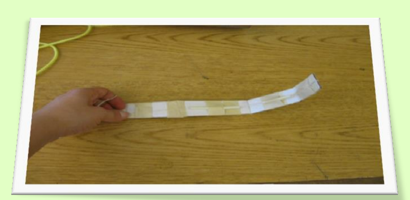


Picture3:Law of Levers

$$F_l \times d_1 = F_e \times d_e$$

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.

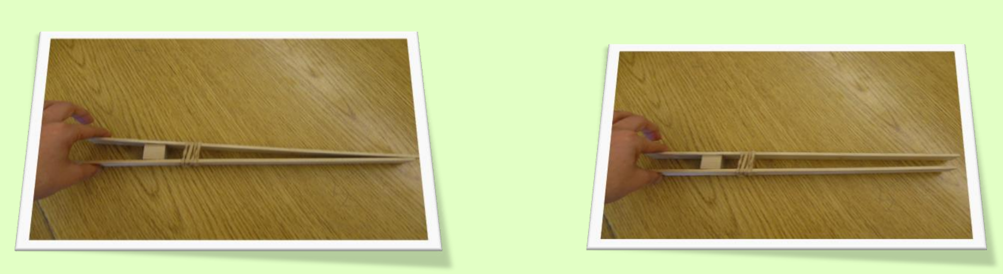


Picture4:Close position *Picture5:Open Position*

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 table3.

Picture6: three different area of pencil (probe) to punch olive

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.



Picture7: Law of Levers

Results

Number	Mesaurment	Length mm
1	Fingertip to knuckle#1	23
2	knuckle#1 to knucle#2	27
3	knuckle#2 to knucle#3	28
4	knuckle to wrist	62

Table1: measurement the length of the each joint of hand

Number	Ratio Measured	Ideal Ratio	Device Ratio
1	Fingertip to wrist	24	29.5
2	wrist to elbow	39.5	42

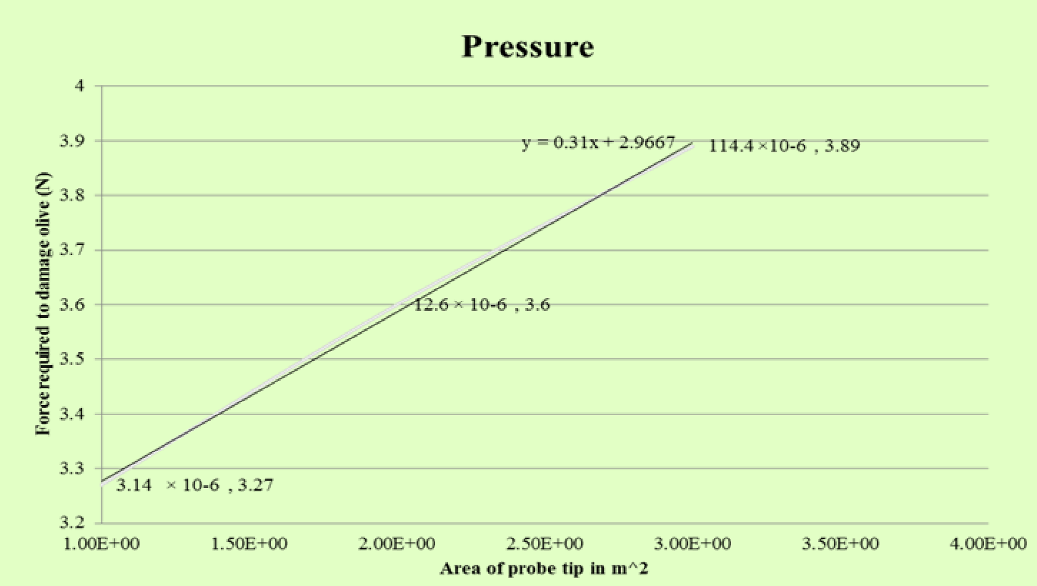
Table2:Finding Golden Ratio in hand and using in designing of device

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

Probe Number	F(N)	A(m²)	P(Pa)
1	3.27	3.14×10^{-6}	1.04×10^{6}
2	3.6	12.6×10^{-6}	0.28×10^{6}
3	3.89	114.4×10^{-6}	29.46×10^{6}
Design			
Max for 2kg	19.6	46.75×10^{-4}	4190

Table3: Force vs.Area

The hypothesis is that with the area of 46.75×10^{-4} the device is able to hold all the objects without damaging them.

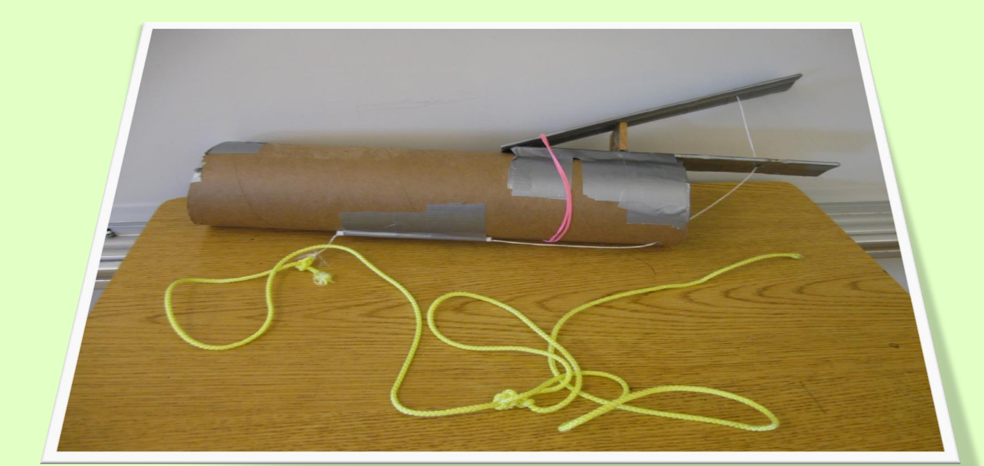


Graph1: Force vs. Area

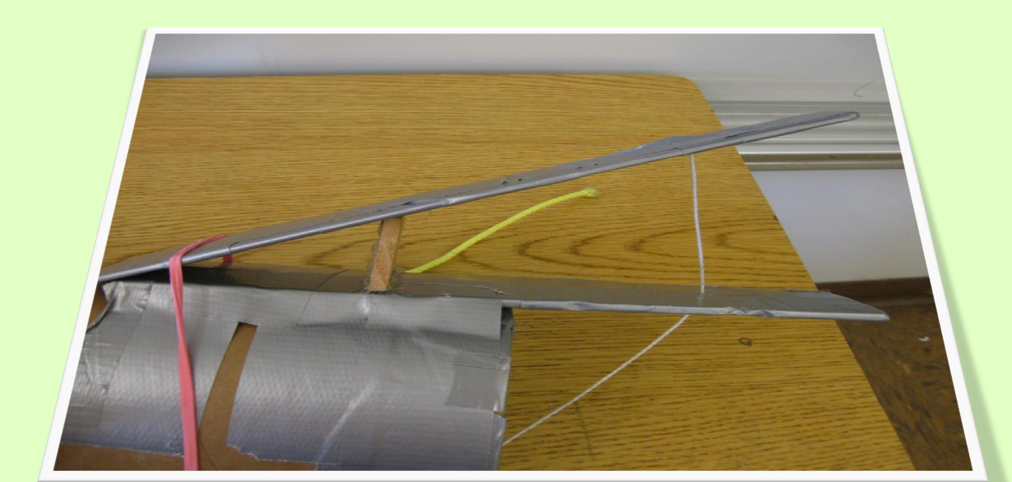
The hypothesis is that with surface area of at least 3.14×10^{-6} for each fingertip the device won't prevent damage to objects encountered in daily life.

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 forcarm parts. The terminal with the maximum force for holding the object with weight of 2kg was divided to two distances of d_l=0.1 m and d_e=0.2m. The force required to pick up the object is 39.2N and comes from moving the arm back and forward.



Picture8: Prosthetic Arm



Picture9: Terminal end of prosthetic arm

References

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Acknowledgments

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Further information

The future of this project is working on electrical part of design and also testing it with disable people.