Design and Fabrication of Prosthetic Hand

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Abstract: **The aim of developing a total prosthetic hand was to achieve hand function as near normal as possible. Since the very complex kinematics of the hand is not at all easy to copy, a compromise had to be found. The prosthetic hands are still a long way from matching the grasping and manipulation capability of their human counterparts in order to overcome this .I have designed this prosthetic hand which can manipulate most of the human hand actions in this paper I discuss about each and every part of this prosthetic hand in detail this prosthetic hand is designed in such a way that the spring responsible for the retractile action and the guide way which is used for actuation is housed within the finger itself this makes the design simpler and effective unlike other prosthetic hands this can achieve a maximum grasp and hold as like our human hand.**

Keywords: **Prosthetic hand, Grasping, Retractile, Actuation, Manipulation.**

I. INTRODUCTION

In today's society robots are used in different areas and applications like in industries and medicine. Especially robot end effectors are of particular interest because they perform the work the robots are designed for; they make it possible to grasp objects or to work up material. Service robotics is another important research. Especially health cares where people who lost a hand or arm can use a robotic grasper to make their everyday life easier. Nowadays the most functional graspers which are available for an affordable cost are having also a low cost design. So because of esthetic reasons people often prefer artificial limbs which have a lower function or no function at all but are looking more humanlike. Yet also in industries a grasper which can perform many different work tasks at a cheap price can be an improvement. So it is important to develop a cheap robotic grasper which can perform everyday grasps. The most hands developed in university research projects are mounted with many actuators and sensors and are for this reason inappropriate for manufacturing in big series and too expensive for the average user.

II. EXISTING DESIGNS

This chapter describes the human hand, and two other robotic hands. First imitations of the human hand are coming from the prosthetic and in the last few years many robotic hands had be developed around institutes all over the world. This chapter shows and describes two different robotic graspers. One the iron hand, one humanoid robot hand without a wrist (The Shadow dexterous hand).

II.I. The Human Hand

Developed under many years of evolution the human hand has made us to what we are today. The human hand is composed by 27 different bones and the opposing thumb is characteristic for the human. The opposing thumb enables the precision grasp between the long finger and the thump which enables us to write or to perform precision work. Further the hand has 20 DOF and the most muscles are placed in the forearm and transmit their developed force via tendons to the fingers. The bigger muscles in the hand are the thenar muscle on the thumb side and the Hypothenar muscle on the side of the little finger.

Fig1: Human hand

II.II THE IRON HAND OF THE REICHSRITTER GOTZ GOTTFREID VON BERLICHINGEN

First imitations of human hands come from the prosthetic, as for example the iron fist of the Götz of Berlichingen (1480-1562). That hand had five separate fingers, which could be bent passively and could be redeemed by pushing a button. The hand had a mass of 1.5 kg what wasn't too bad for that time.

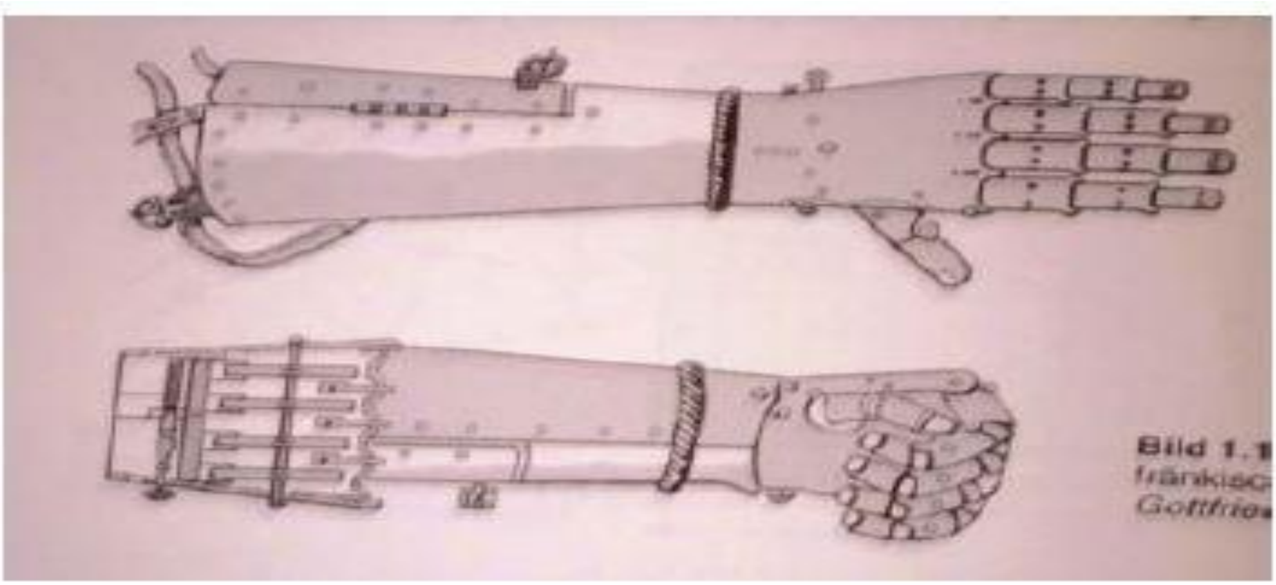


Fig2: The Iron Hand

II.III. THE SHADOW HAND

The Shadow Dextrous Hand is an advanced humanoid robot hand. The hand can perform 24 different grasps and is as close as it gets to a human hand. The hand has a total mass of 3.9 kg including all sensors and actuators. It's built from a plenty different materials; the forearm bone is made of steel, the palm is made of acetyl, aluminum and polycarbonate and the fingers are made of acetyl. The hand is driven by 40 air muscles (40 degrees of actuation).
which are mounted on the forearm. These are connected with tendons too the joints. The air muscle technology requires both electric current and compressed air. The hand is equipped with tactile sensors at the finger tips for feedback control. Each sensor has an output range from zero up to one kg.

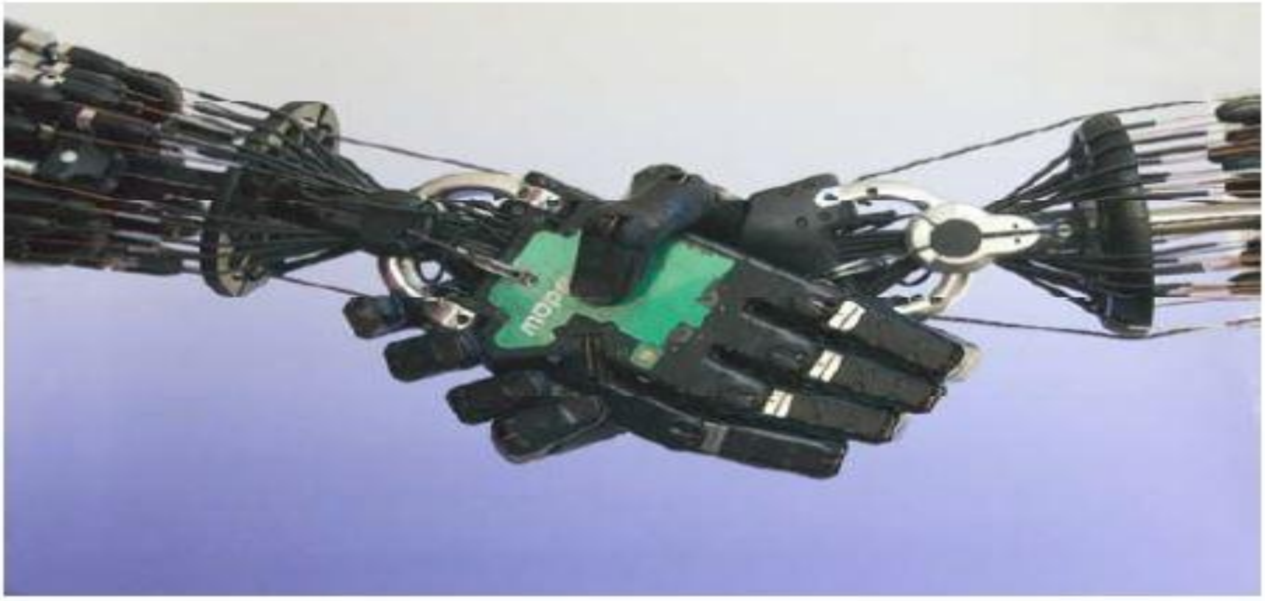


Fig 3: The shadow hand

3. THE FINGER

The finger consists of three parts that is the phalanges are divided into three flexible parts as in the human hand and these three parts are milled separately and pivoted together with the help of the aluminum revert the spring is also housed inside the joints lets us see each part in detail

III.I Phalange 1

Phalange 1 or the part 1 referred in here is the smallest of the of the three parts this part is obtained from milling aluminum block which has been cut for the required shape in this milling and drilling process the guide way for the actuation and the hole for pivot are obtained as shown below in Fig4.

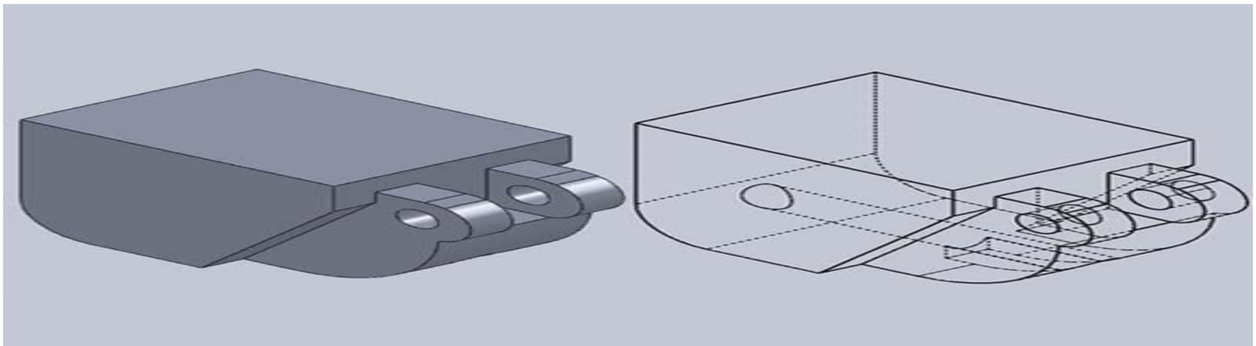


Fig4: Finger part 1 or Phalange 1

III.II Phalange 2

Phalange 2 or the part 2 referred in here is the middle portion of the finger and this part holds the phalange1 and phalange 2 together and this part also has enough room to house the phalange 1while in bent position thus providing the maximum grasping force the phalanges are curved at the bottom and top to avoid pinching of the grasping object the detailed view of the part is as shown below in Fig 5.

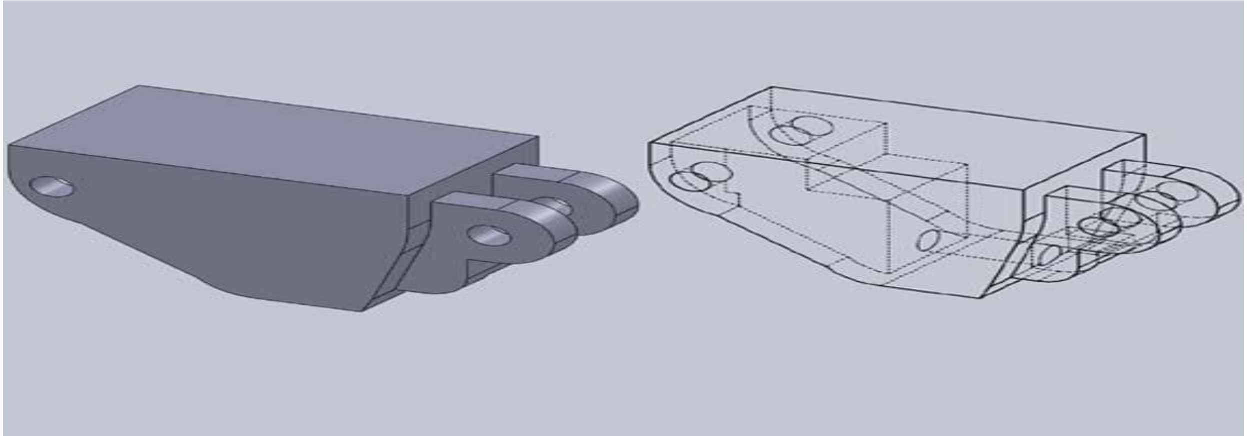


Fig 5: Finger part 2 or Phalange 2

III.III Phalange 3

Phalange 3 or the part 3 referred in here is the last part of the finger and this is responsible for connecting the fingers with the palm and this part also has been designed to provide room for the phalange 2 when it bends and this bending can achieve a maximum of 90 degrees as in human hand let us see the part in detail in Fig 6.

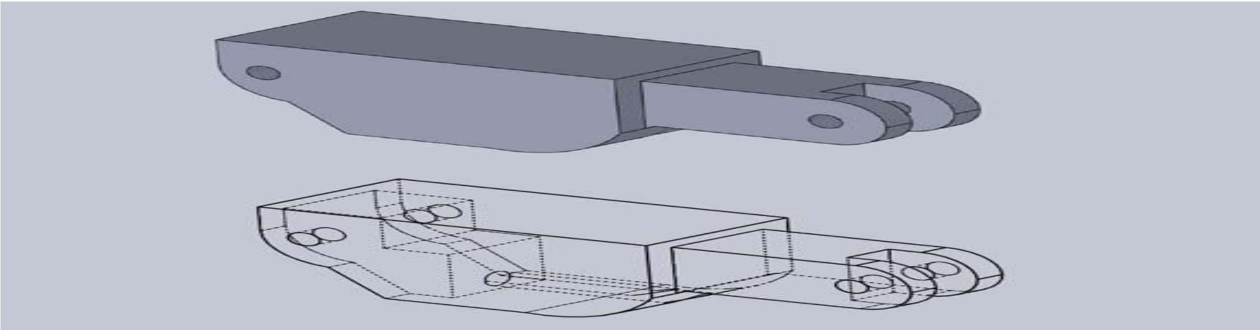


Fig 6: Finger part 3 or Phalange 3

IV. PALM

The palm is designed with the cover on its back side the cover is designed in such a way that if there arises a problem in the actuation of the finger the cover can be removed for maintenance and the palm is designed in such a way that it houses 4 fingers that is it has 3 fingers and 1 thumb the tendon which passes through the guide way along phalange 2 and phalange 3 and through the palm and reaches the actuation source the thumb is fitted at angle to the palm this can be clearly observed from the diagram below in Fig 7.

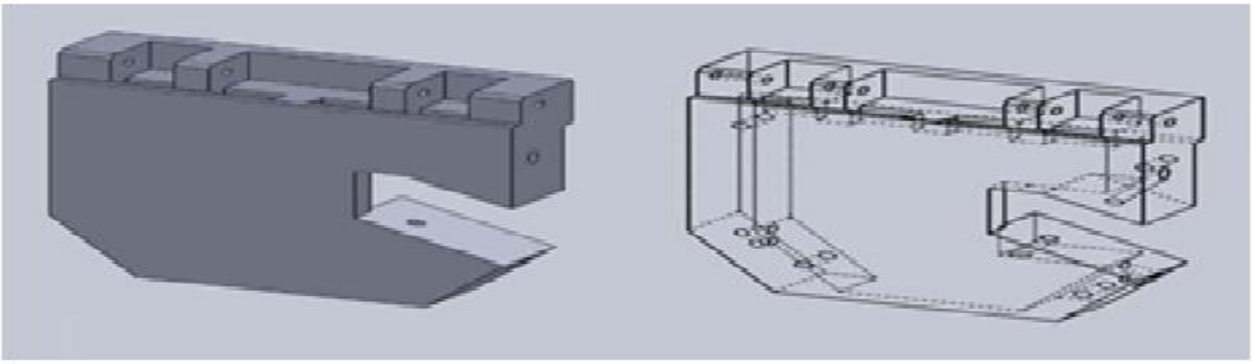


Fig 7: The palm

V. THUMB

The thumb consists of 2 parts or 2 phalange the phalange 1 of the thumb is slightly longer than that of the other three fingers and the phalange 2 is assembled at an angle to the palm this helps in holding of the object this is given in Fig 8.

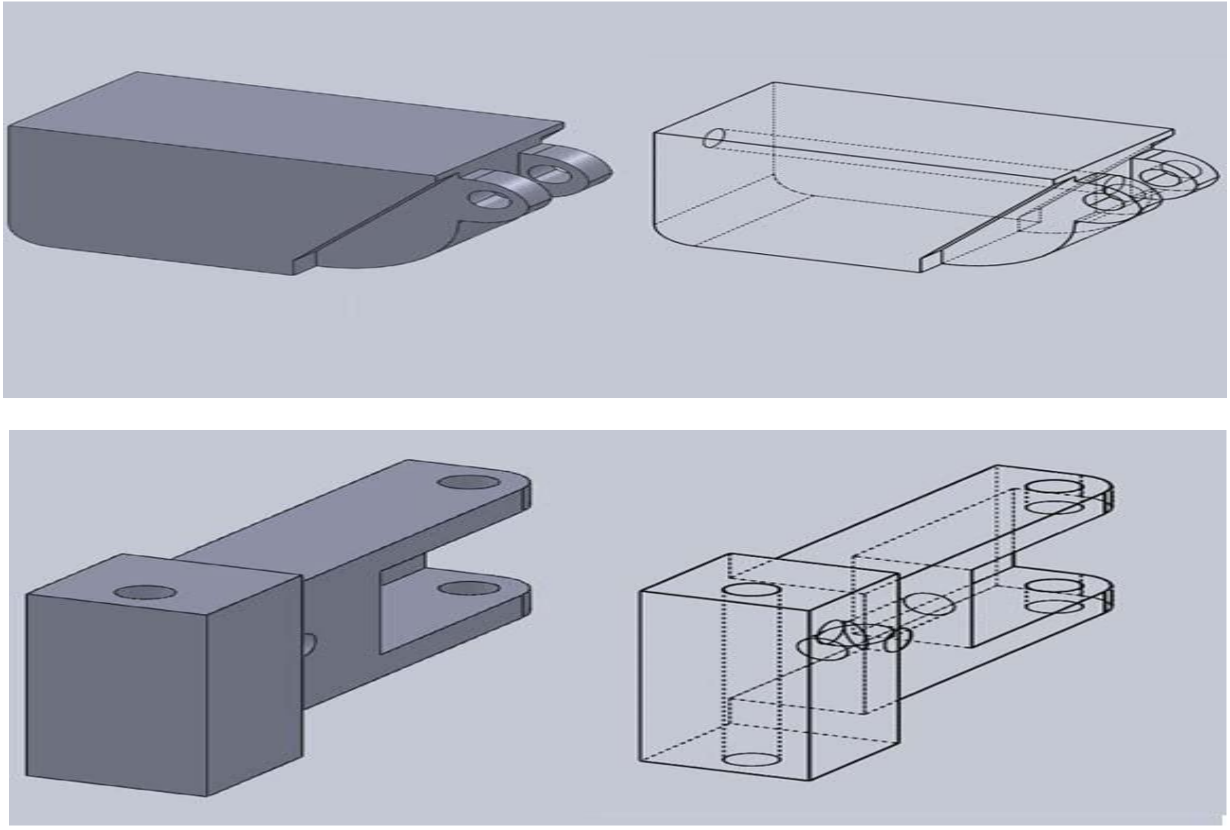


Fig 8: Thumb phalange 1 and 2

VI. ACTUATION

The actuation of the fingers are carried out using servo motors since the main aim was to design a low cost high capability prosthetic hand the servos are housed in the forearm and the tendon is used for transferring the torque from the servo to the finger.

VII. THE WHOLE ASSEMBLY

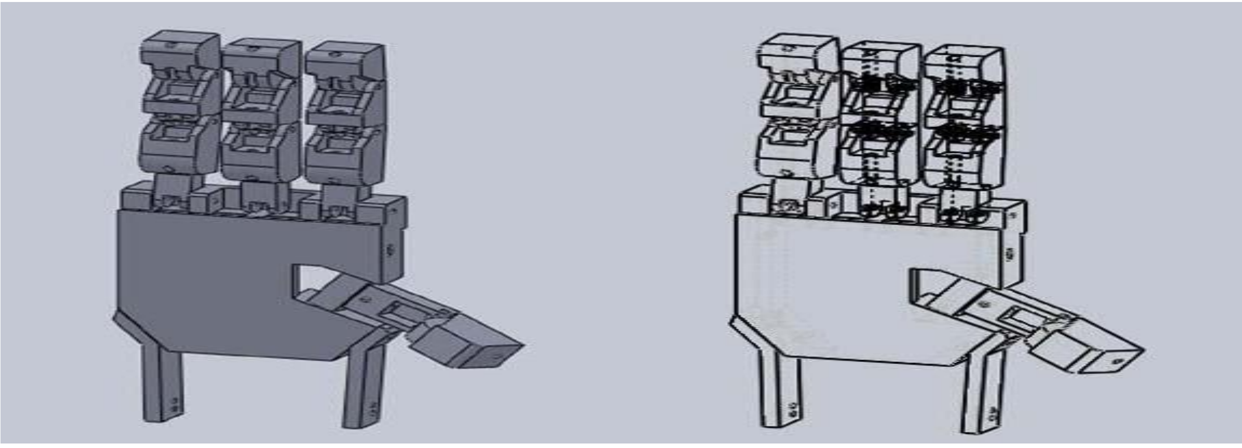


Fig 9: The whole assembly

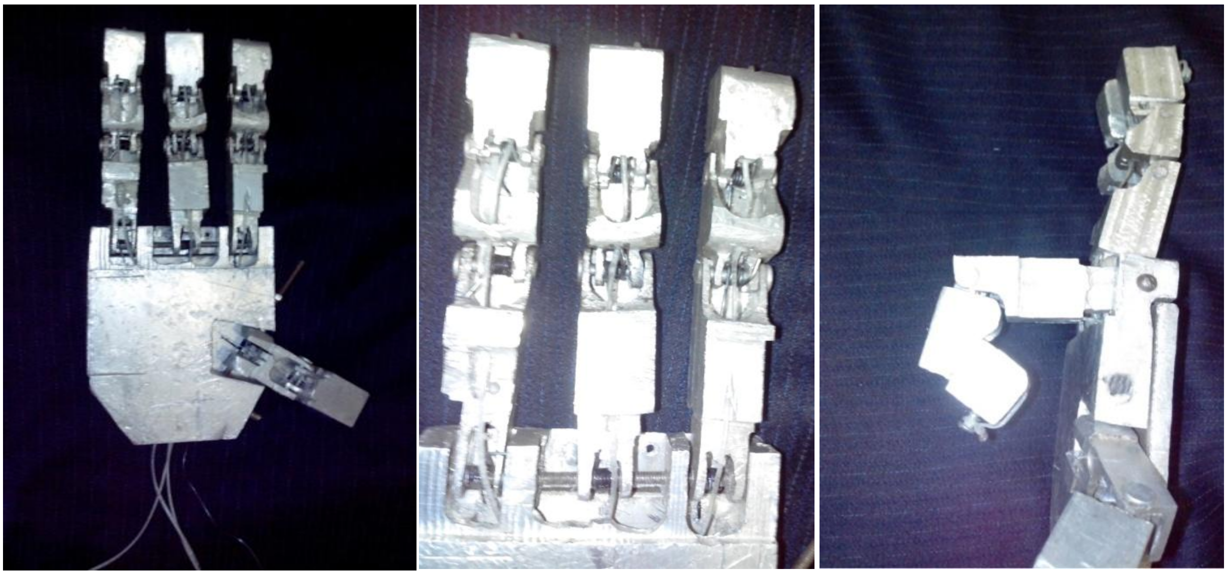
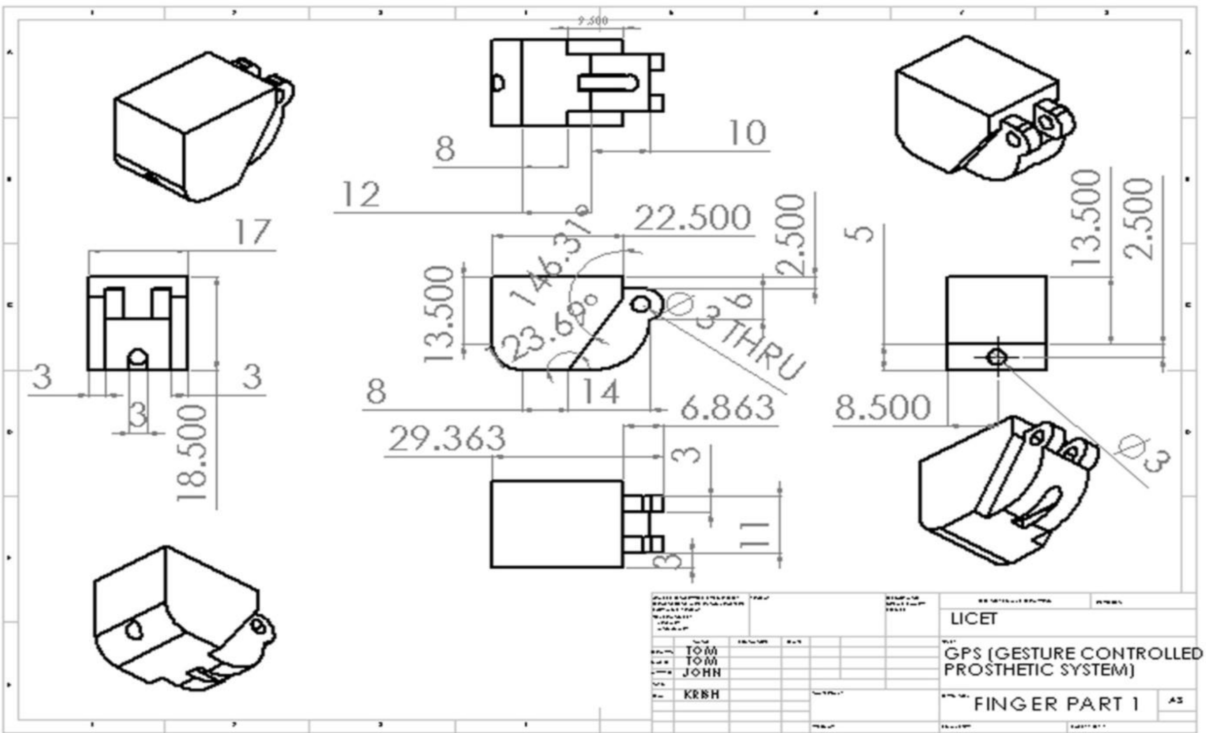


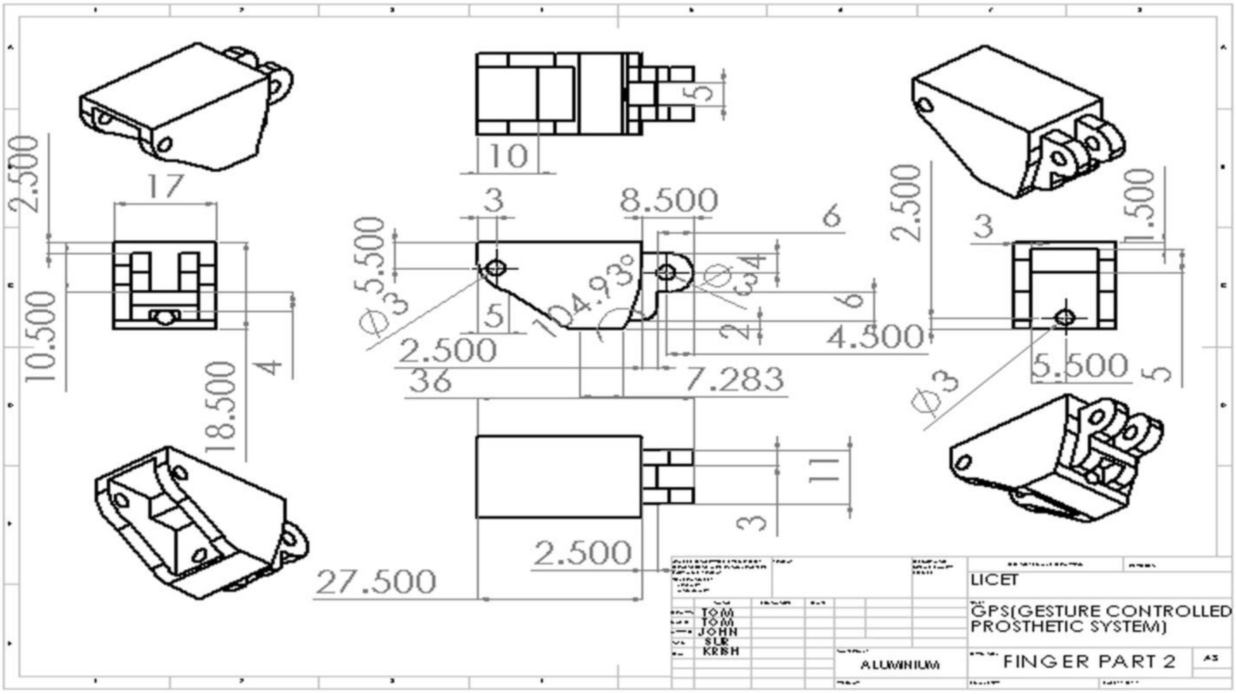
Fig 10: The actual hand after fabrication

VIII. CONCLUSION

This four finger robot hand could be developed at a total project cost of Rs 2000(excluding actuation part). The main parts of the hand are manufactured by Milling. That method made it possible to manufacture all parts to one price and was also timesaving because just a few drawings had to be made. By redesigning the hand backside in a lighter construction the hand can become between 8-10 % lighter. Nowadays it would become necessary to change all actuators and sensors, so the hand backside is designed for removable standards. The new hand can perform two more grasps using the palm and can grasp objects in a better way. Also the assembly properties and cable routing could be improved. Last but not least the new hand has dimensions close to the human ones and looks humanlike.

IX. DRAWINGS




10
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17
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104.93°
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2
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36
7.283
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11
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2.500
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LICET
GPS(GESTURE CONTROLLED PROSTHETIC SYSTEM)
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TOM
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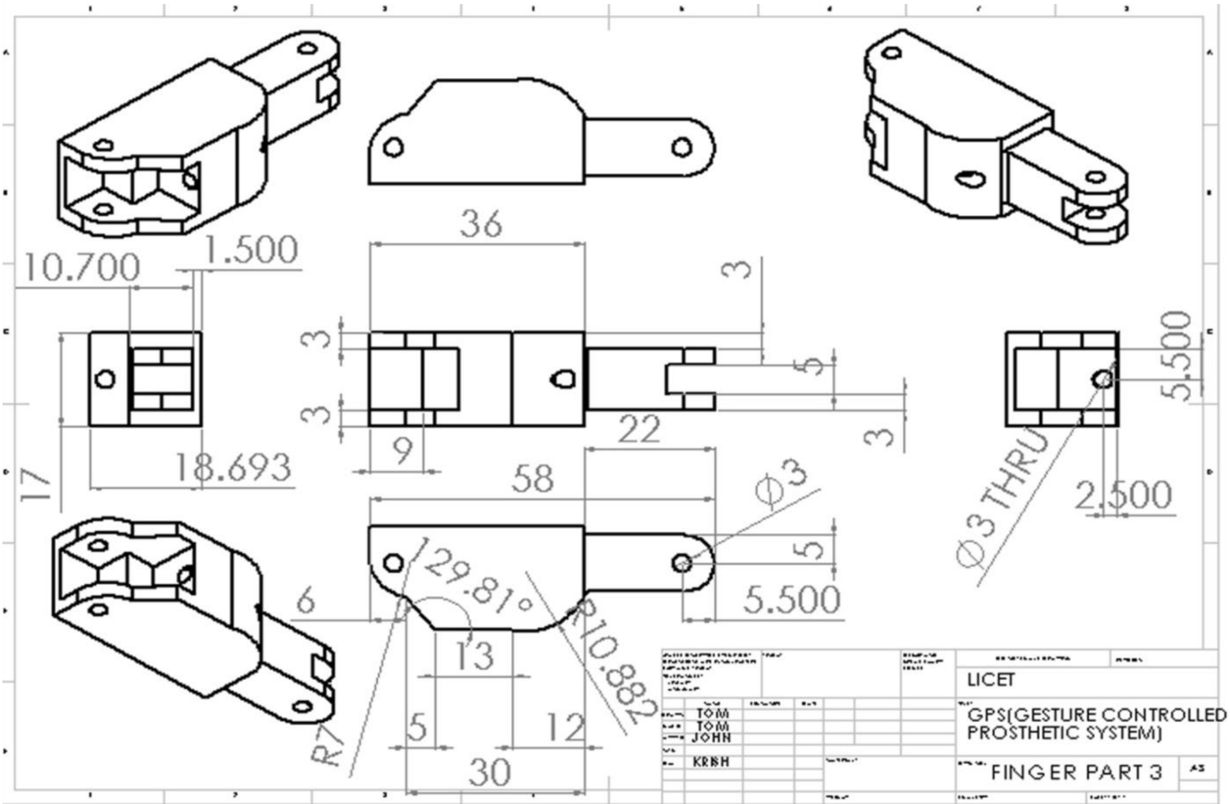
ALUMINIUM
FINGER PART 2
A3


36
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6
129.81°
R10.882
5.500
13
5
12
R7
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LICET
GPS(GESTURE CONTROLLED PROSTHETIC SYSTEM)
TOM
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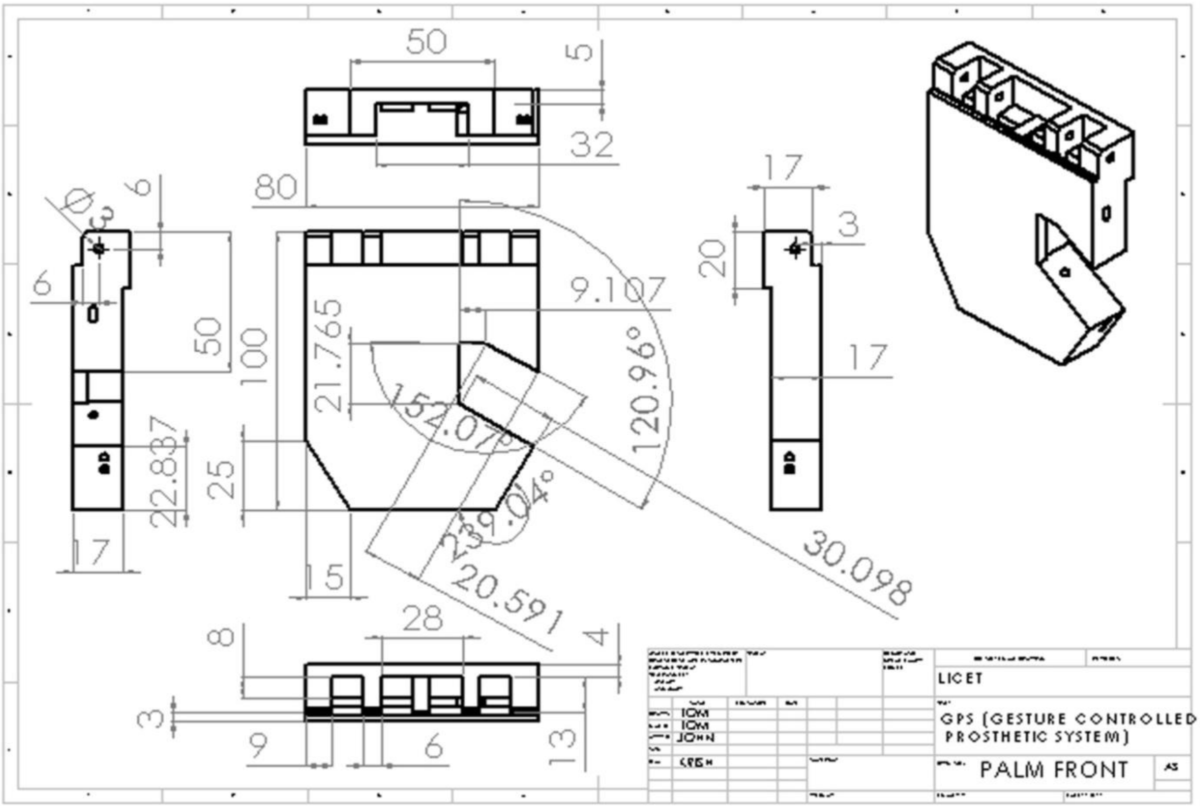
JOHN
KRISH
FINGER PART 3
A3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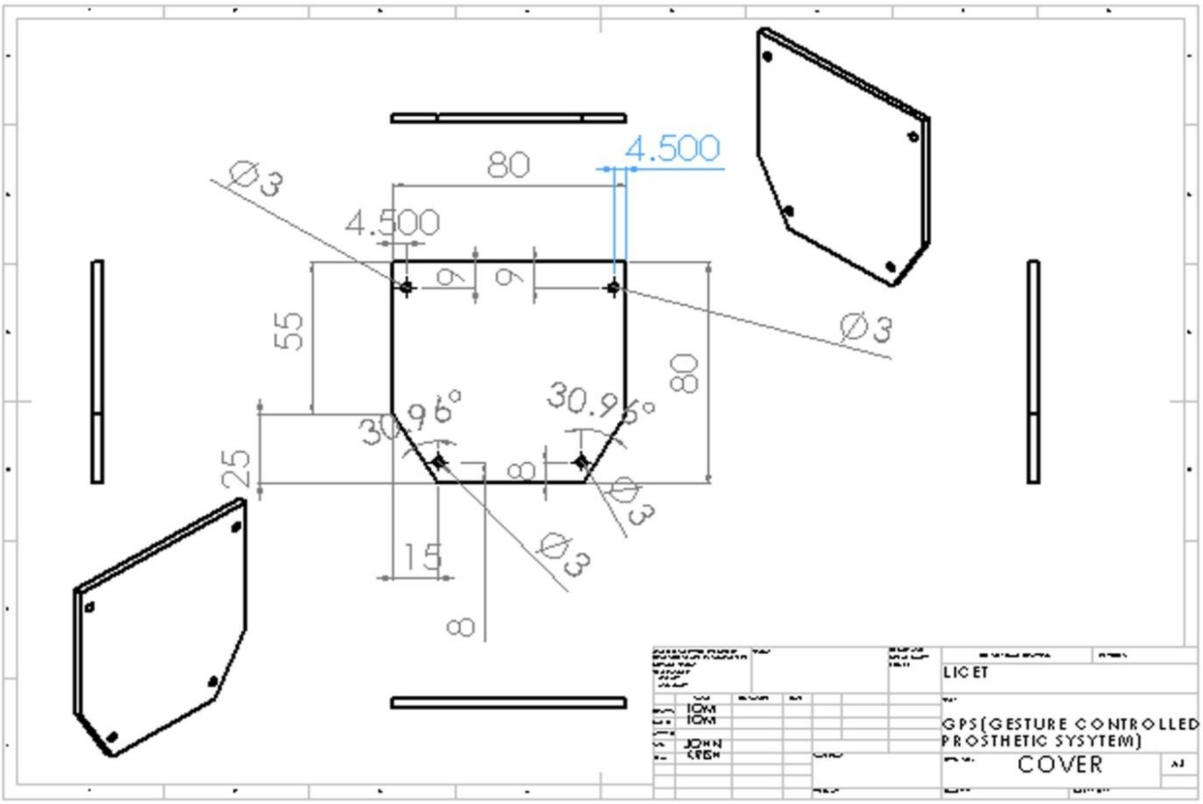
GPS (GESTURE CONTROLLED PROSTHETIC SYSTEM)
PALM FRONT
JOHN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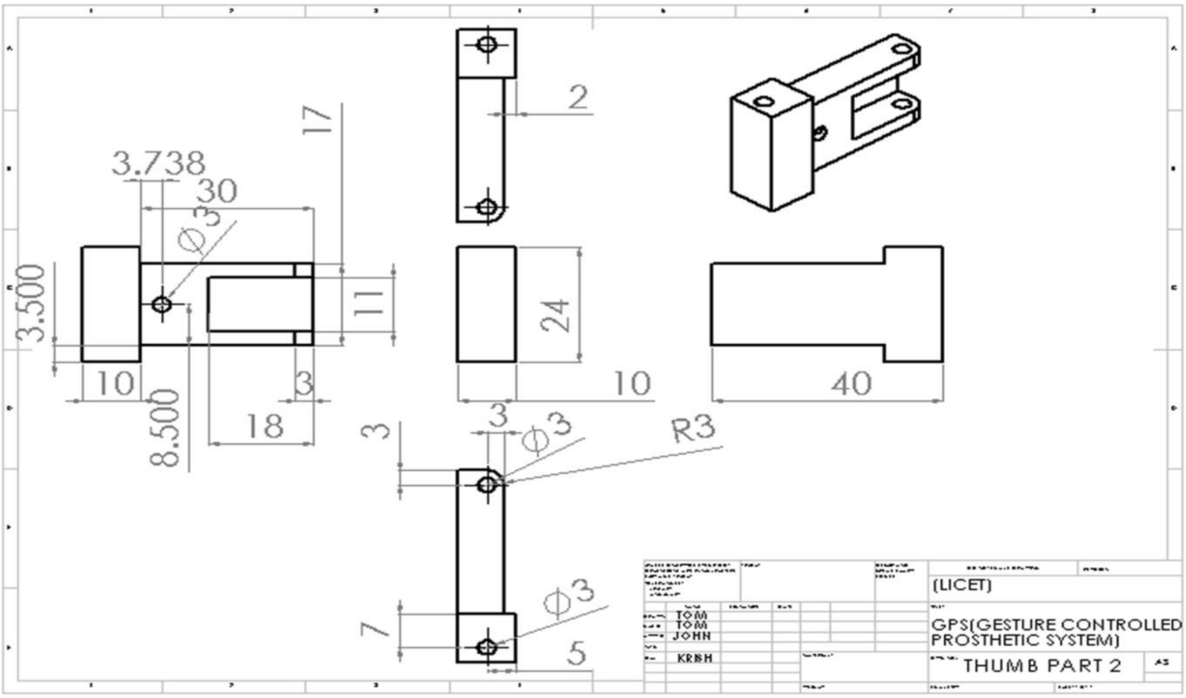
GPS(GESTURE CONTROLLED PROSTHETIC SYSYTEM)
COVER
JOHN



REFERENCES

[1] M. Anitescu and F. A. Potra. Formulating dynamic multi-rigid-body contact problems with friction as solvable linear complementarity problems. Nonlinear Dynamics, 14:231.247, 1997.

[2] Y. Bar-Shalom, X. Li, and T. Kirubarajan. Estimation with applications to tracking and navigation. John Wiley and Sons, Inc., New York, 2001.

[3] C. Borst, M. Fischer, and G. Hirzinger. A fast and robust grasp planner for arbitrary 3D objects. In Proc. of the 1999 IEEE Intl. Conf. on Robotics and Automation, pages 1890.1896, 1999.

[4] P. Corke. A robotics toolbox for MATLAB. IEEE Robotics and Automation Magazine, 3(1):24.32, Mar. 1996.

[5] R. W. Cottle, J. S. Pang, and R. E. Stone. The Linear Complementarity Problem. Academic Press, 1992.

[6] D. Ding, Y.-H. Liu, and S. Wang. Computing 3-D optimal formclosure grasps. In Proc. of the 2000 IEEE Intl. Conf. on Robotics and Automation, pages 3573.3578, 2000.

[7] M. Garcia-Elias, K. N. An, L. Berglund, R. L. Linscheid, W. P. Cooney, and E. Y. Chao. Extensor mechanism of the _ngers: I. a quantitative geometric study. J Hand Surgery (American), 16:1130. 1140, 1991a.

[8] W. R. Gilks, S. Richardson, and D. J. Spiegelhalter. Markove Chain Monte Carlo in Practice. Chapman & Hall/CRC, Boca Raton, FL, 1996.

[9] D. J. Giurintano, A. M. Hollister, W. L. Buford, D. E. Thompson, and L. M. Myers. A virtual _ve-link model of the thumb. Medical Engineering and Physics, 17(4):297.303, June 1995.

[10] E. Grinspun, P. Krysl, and P. Schr¨oder. CHARMS: a simple framework for adaptive simulation. In Proc. of the 29th annual conference on Computer graphics and interactive techniques, pages 281.290. ACM Press, 2002.

[11] R. D. Hester, M. Cetin, C. Kapoor, and D. Tesar. A criteria-based approach to grasp synthesis. In Proc. of the 1999 IEEE Intl. Conf. on Robotics and Automation, pages 1255.1260, 1999.

[12] D. Kragi´c, A. Miller, and P. Allen. Real-time tracking meets online grasp planning. In Proc. of the 2001 IEEE Intl. Conf. on Robotics and Automation, pages 2460.2465, 2001.