A Project Report

On

ADAPTIVE FINGER DESIGN

BY

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Under the supervision of

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I would like to express my heartfelt gratitude towards Dr. Abhishek Sarkar, Mechanical Department for giving me an opportunity to be part of the project and guiding me at every stage. I am thankful to him for allowing me to work on this project at my convenient time, even after lab hours. I am turly grateful for his unyielding guidance.

Birla Institute of Technology and Science-Pilani,

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Certificate

This is to certify that the project report entitled "**Adaptive Finger Design**" submitted by Mr. Cheekati Shashank Raghav (ID No. 2020B3A40543H) in partial fulfillment of the requirements of the course ME F366, Laboratory Project Course, embodies the work done by him under my supervision and guidance.

Date: 7th November 2022 **(ABHISHEK SARKAR)**

BITS- Pilani, Hyderabad Campus

ABSTRACT

Human Hand is a very complicated and a complex design. It can perform tasks ranging from heavy weight lifting to miniature art making. It has both the ability to be precise and dexterous. It can manuvere multiple finger movements like cylindrical grip, pinch grip, prehension, etc. To be able to replicate and utilize this highly functional mechanism of hand is every Engineer’s dream. It has applications like Prosthetics/Bionic hands, Humanoid robots and many other industrial applications which require human intervention can be replicated by these hands. Through this project I plan on developing an Antromorphic hand which can be utilizied for many applications.

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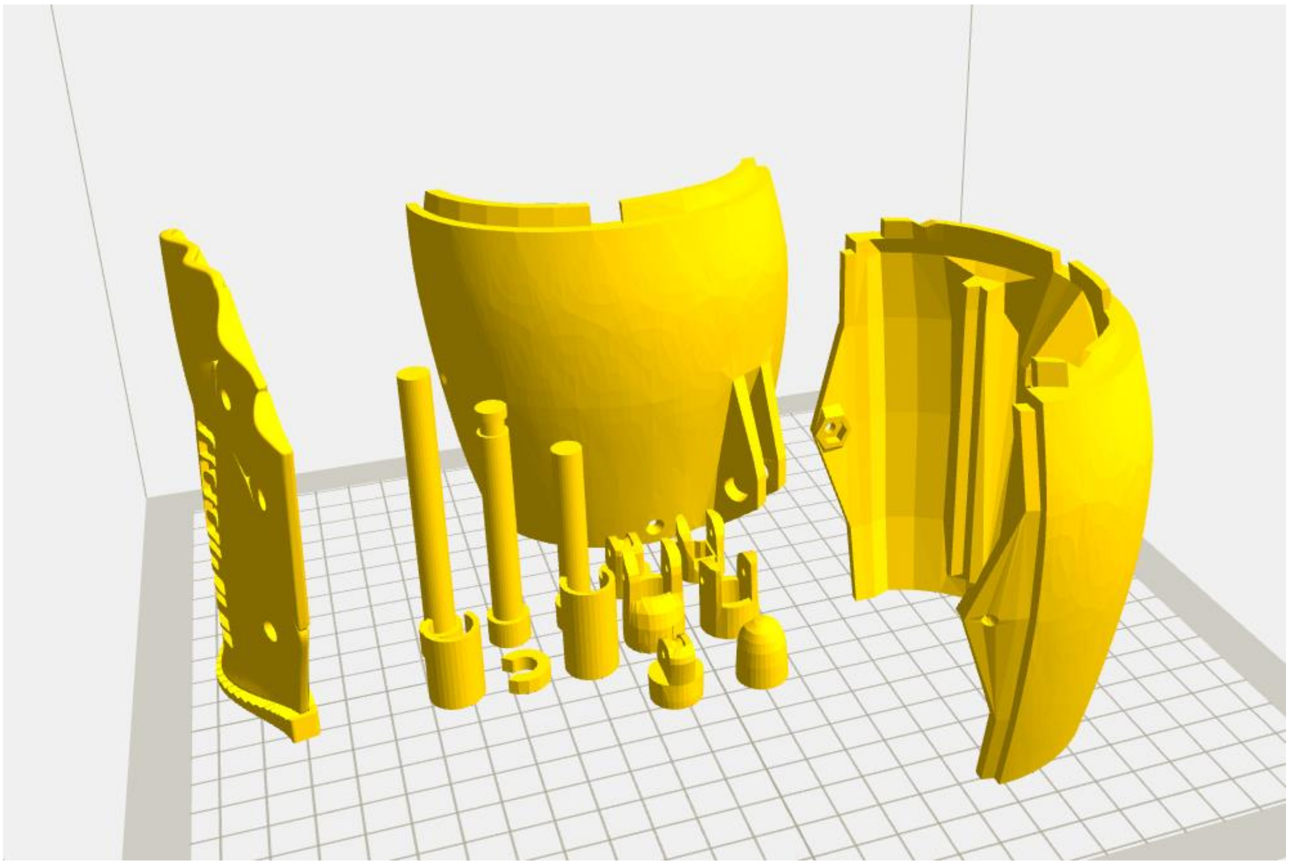
Design and Working Mechanism –

The Design of the arm is based of InMoov a Humanoid robot. The mechanism implemented in this model is called “Tendon Driven Mechanism” which is very commonly and widely utilizied by Engineer’s researching robotic hands. In this mechanism tendons, strings, mostly fishing wires, are run through out the finger from finger tip to the forearm where this wire ends on top of an actuator. For this case I used Servos as the actuators due to their precise control.

Design :

All the parts are modelled in CAD. Due to this there a high scope of modifications and changes as well as command over 3D prints. Here 3D printing was extensively used to fabricate all the parts and assemble them.



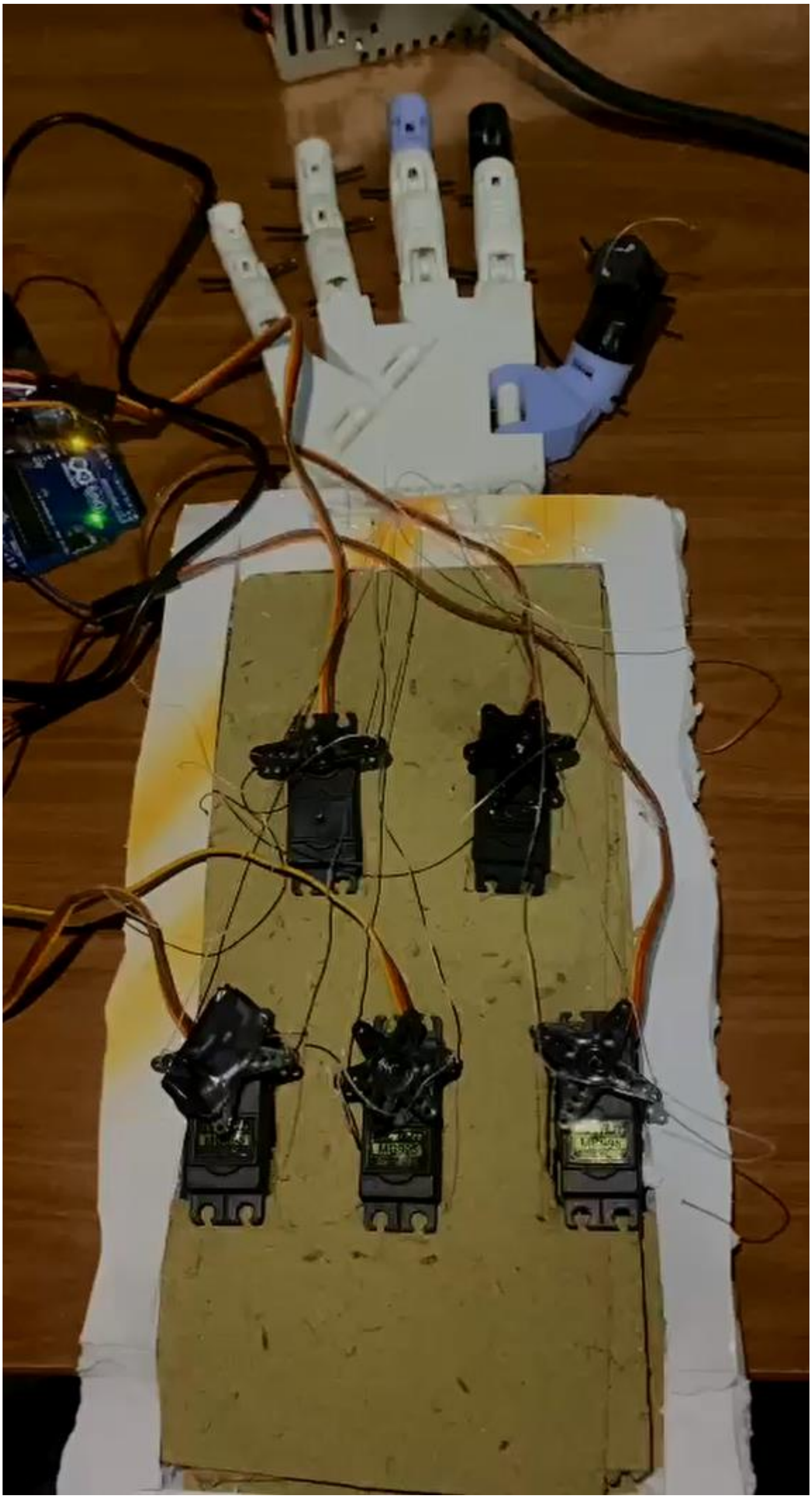
Some CAD parts viewed in the slicer

This picture shows the hand when completely assembled together. It is still not fully assembled hence there are some changes and additions that need to be done.

Mechanism:

Mechanism as mentioned before is Tendon Driven where Tendon like string end up controlling the fingers. Tendons are the parts in our body that are responsible for muscle movements. The strings used in the robotic arm are going to replace the tendons. The control unit for this arm is Arduino Uno. It keeps sending signals to the servos to control them. Later a Raspi will be used to control the arm.

In the initial prototype, as shown below, nylon thread is used as tendons and servos as actuators along with an Arduino board. The hand is powered by a “Switch Mode Power Supply” (SMPS) operated at 5V.



Literature Review:

Use of flexible fluidic actuators:

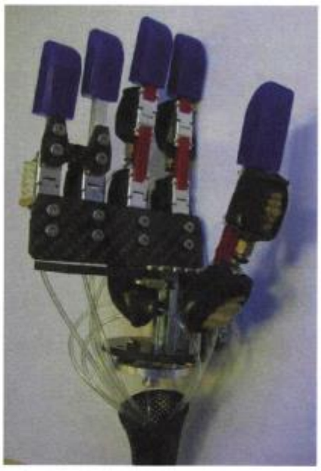
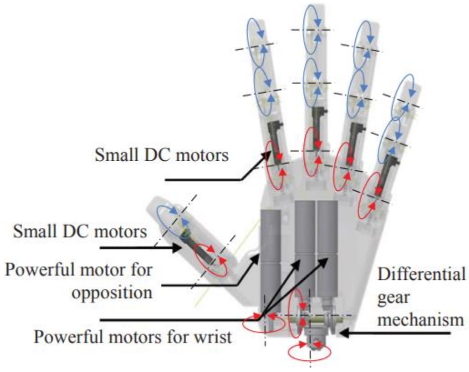


Fig. 3: Precise Three jaw grasp of the robotic hand

The paper presents the use of pneumatic actuators to achieve strength and a retraction mechanism.

Use of Springs and many small DC Motors for each degree of freedom:



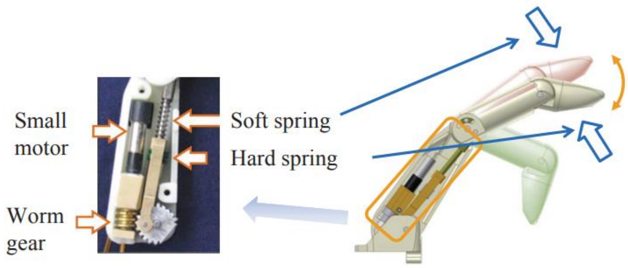


Fig. 16. Passive mechanism of finger.

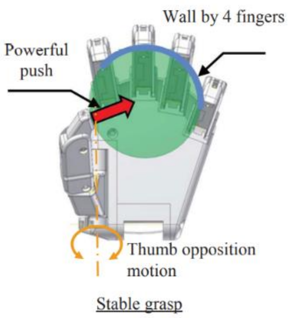


Fig. 15. Grasping strategy.

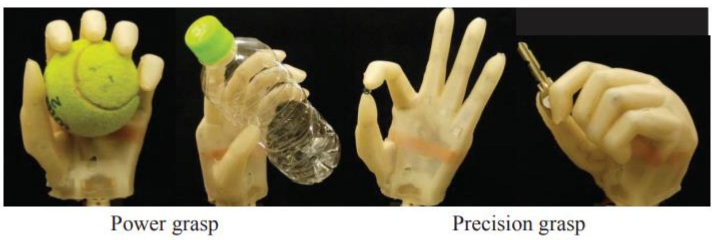


Fig. 17. Grasping various types of objects with artificial skin. From left: tennis ball, plastic bottle, screw nut, and key.

This paper presents a mechanism using many dc motors of small sizes and springs to control the hand. This mechanism gives excellent results but is very hard to manufacture and control.

Multi–sensor Data Fusion:

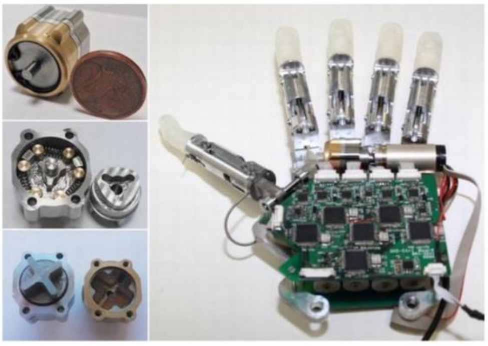
A multi-sensor feedback mechanism using piezoelectric material, polyvinylidene fluoride (PVDF), to gather electrical signals. Adjust grasping based on the orders received by data fusion. It can even bounce off high-temperature objects.

Invasive and Non-invasive Sensory Feedback:

This article reviewed sensory feedback on both non-invasive and invasive sensors. Non-invasive techniques include mechanotactile, vibrotactile, electrotactile and a combination of these systems. Invasive methods include both extraneural and intraneural electrodes.

Robotic Thumb with Abduction and Adduction:

This paper presents a solution to achieving the highly complex thumb mechanism. It discusses topics from mechanism to forces and strains generated in the hand during manipulation. It also gives a detailed kinematic, static and stiffness analysis and experimental measurements.



Multi-DOF electromyography based prosthetic hand using adaptive joint mechanism:

In this paper, they propose an adaptive joint mechanism based on tendon-driven architecture. It includes mechanical torque-velocity converters and a mechanism to assist the proximal joint torque by distal actuators. It also discusses EMG signals. 12 servo motors are driven to move the adaptive joint mechanism.

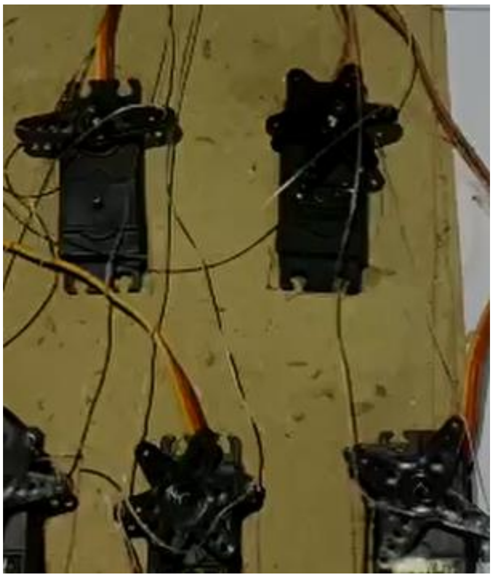
Realistic motion and touch:

This article talks about the realistic touch through technologies like smart artificial skin. It talks about MIT's scalable tactile glove, which has 548 tiny sensors that gather pressure-signal data. Using this technology, they identified various objects with a success rate of about 75 per cent. They also talk about NUS' Asynchronous Coded Electronic Skin (ACES) which can detect touch 1000 times faster than the human sensory nervous system.

Different wires as Tendons:

Nylon wire:

Nylon was the initial choice for using as tendon. It has good flexibility and good tensile strength. After a few tests, issues started arising. The main issue is, the nylon wire was stretching. For the mechanism to work the tendon needs to be under tension all the time. Because of it's elongation it is under going a plastic deformation. Hence nylon was ruled out.



Manja wire:

Manja wire is made of fine pure cotton thread coated with a mixture of rice glue, tree gums and an abrasive : finely powdered glass, aluminum oxide or zirconia alumina.

The next choice was the kite flying, very easily available manja wire. Although the one on which tests were conducted was not fully manja but had similar strength. After a few tests, another set of problems came forth. Since it being a wire stranded together with many threads, after a few test runs it was unstranding, becoming weak. Hence, this was also ruled out.

Veena Strings wire:

These wires are metal wires. Hence they had very low flexibility. Due to this, even when attaching the wire to the hand only it experienced fatigue like phenomenon. Also due to their low elongation capacity, when testing out the mechanism the wires broke, meaning material failure happened. Hence this was also ruled out.

Final Conclusions on Wire Material:

After testing out a few materials and their effects, to fully utilize the potential of the hand's mechanism we need a wire material with high tensile strength and high elastic modulus. Also, it should have a certain amount of flexibility. This is what that can be inferred from these different test run. To test ou the material performing an Uni-axial Tensile Test (UTM) will give better inferences. The reason being simple, throughout the work time of the hand the wires will always be under Tensile Load.

Future Plans –

So far only the fabrication and initial test of the mechanism have been done. Currently I wish to first finish the entire Assembly and then wish to control all the 5 fingers as part of the second phase. Later as part of the third phase I would like to implent Machine Learning Algorithms to train the arm in some gripping patterns as mentioned above. Later I would also like to implement wrist

Conclusion :

So far I have been able to grasp the working of the hand utilizing the design of InMoov. The design is very robust and excellent. It can closely mimic the humand hand. It also has the ability to adapt to any kind of design that we want to make. Many Creators take InMoov as a base an arm that are developing and build over it.

References :

- CAD Model of the design
- Build Reference 1
- Build Reference 2
- Mechanim & Design 1
- Mechanism & Design 2
- A bionic manipulator based on multi-sensor data fusion
- A review of invasive and non-invasive sensory feedback in upper limb prostheses
- Non-back-drivable rotary mechanism with intrinsic compliance for robotic thumb abduction/adduction
- Development of a multi-DOF electromyography prosthetic system using the adaptive joint mechanism
- Advances in Prosthetics Create Realistic Motion and Touch