DEVELOPMENT OF 3D PRINTED ROBOTIC HAND

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ABSTRACT

The robotic hands that appear and act as human hands are built in a manner that makes them very similar to the actual thing that is programmable. In fact, most of these hands feature tendons (cables) and fingers that work together much like human hands do to open and close for the manipulation of objects. In order to build a humanoid robot, building a robotic hand plays an important role. Its role is to grasp and manipulate the objects without damaging them from one place to another in any intrinsic environment. This also acts as an end effector for any manipulator. It is not only used as the hand of a humanoid robot but also in rehabilitation medicine, i.e., as a prosthetic hand. Also used in some hazardous environments like mining, nuclear plants, or space applications that reduce human interactions with an environment, which is an advantage to mankind by reducing human damage during working in the above-mentioned environments. It also has many opportunities in many areas. Hence, in this project, a five-finger robotic hand with almost an equal number of DOF to the human hand is developed to perform the human grasps. The robotic hand is driven by a method that employs servo motors, springs, and cables. The method makes use of restoring force as driving power in grasping objects, which enables the robotic hand to perform a stable and compliant grasping motion. The robotic hand modelling is done with the help of SOLIDWORKS software according to the required specifications and fabricated by using one of the 3D printing processes, FDM (fused deposition modelling), and further control experiments are conducted. As a result, the potential of the robotized hand is confirmed.

KEYWORDS: Arduino Nano, servo motors, potentiometer sensors,3D Printer.

1.INTRODUCTION

A robotic hand, also known as a robot gripper or robotic end effector, is a mechanical device designed to mimic the capabilities and functions of a human hand. It is an essential component of robotic systems that interact with the physical world, allowing robots to grasp, manipulate, and handle objects with precision and dexterity.Robotic hands are developed to perform tasks that require fine motor skills and delicate control, such as picking up objects of various shapes, sizes, and weights, manipulating tools, or operating machinery. These hands are typically equipped with sensors and actuators, enabling them to sense and respond to their environment. The design of robotic hands can vary depending on the specific application and desired functionality. Some robotic hands replicate the structure and movement of the human hand, consisting of fingers, joints, and a palm, while others may have a more specialized form suited for specific tasks.

The fingers of robotic hands are often articulated, allowing them to trimmer potentiometer and bend like human fingers. Additionally, some robotic hands incorporate tactile sensors on the fingertips to provide feedback about the objects they are interacting with and enabling them to adjust their grip and apply appropriate force. Robotic hands can be controlled through a variety of methods, including manual teleoperation, pre-programmed movements, or advanced algorithms based on machine learning and artificial intelligence. Some robotic hands are also equipped with force sensors or torque feedback systems, allowing them to exert controlled force or adapt their grip strength based on the object being handled.

Applications of robotic hands are diverse and can be found in various fields, including manufacturing, healthcare, space exploration, and prosthetics. In manufacturing, robotic hands are used in assembly lines to manipulate and assemble components quickly and accurately. In healthcare, they can assist in surgical procedures or aid individuals with disabilities. In space exploration, robotic hands are used on robotic arms to perform tasks in extraterrestrial environments. Overall, robotic hands play a crucial role in advancing automation and robotics technology, enabling machines to perform intricate tasks that require the dexterity and adaptability of the human hand.

2.METHODOLOGY

Our project basically represents step-wise procedure for manufacturing robotic arm using 3D printed parts of the robotic hand which includes different separated parts when we join them it makes the finger of arm and a servomotor case, in which we join the servo motor which is connected to the fingers, Arduino Nano, and sensors. The proposed system has sensors as input which is controlled by user's other hand. In this paper Arduino board is connected to the input and output that is it controls the whole mechanism of the system through the code or program given to the board and performs the successful functioning of the prosthetic hand. It is very helpful to perform daily life activities and it also wide applications in industries where harmful chemicals products are used which can damage the human skin. The robotic hand consists of five fingers designed using three-dimension 3D printer. Each finger has three degree of freedom (3-DOF) and it is controlled by one servomotor for actuating with angle of rotation from 0° to 180°.

The first step we took when designing the robotic hand was to decide on the best control mechanism for finger movement. The goal for our design was to minimize the number of actuators necessary to control the movement of the finger and simplify the equations needed to describe the motion of the finger. There are very many ways to do this and we explored as many options as possible. There were several preliminary designs we dealt with before choosing what we decided was the best approach. These designs ranged from a tension controlled device, to pulley systems with different levels of complexity. We considered the tension controlled model, consisted of the three joints of the finger, with a cable attached to a fixed point on each link of the finger which was run back through the finger to an actuator mechanism at the hand or behind the wrist. There were two main approaches to this design. The first, as shown in Figure 2.1, consisted of cables run over the joints between each link of the finger, which would pull the links upwards when tension was applied to each cable. For this model, each joint would have a compliant mechanism which forced the resting state of the links to be in the bent position. The second approach for this design has the complaint mechanisms such that the resting state for the links is in the straightened positions. The tension from the wire itself causes the finger to bend downwards, as shown in Figure 2.2.

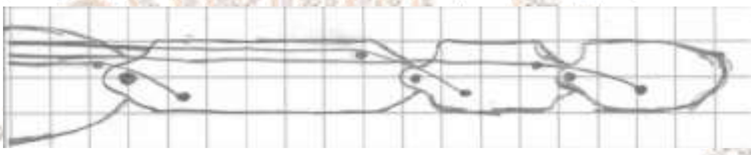


Fig 2.1 Multiple Tension Cable Design Proposal

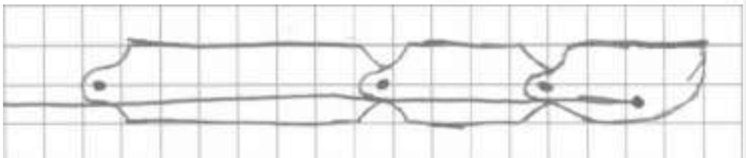


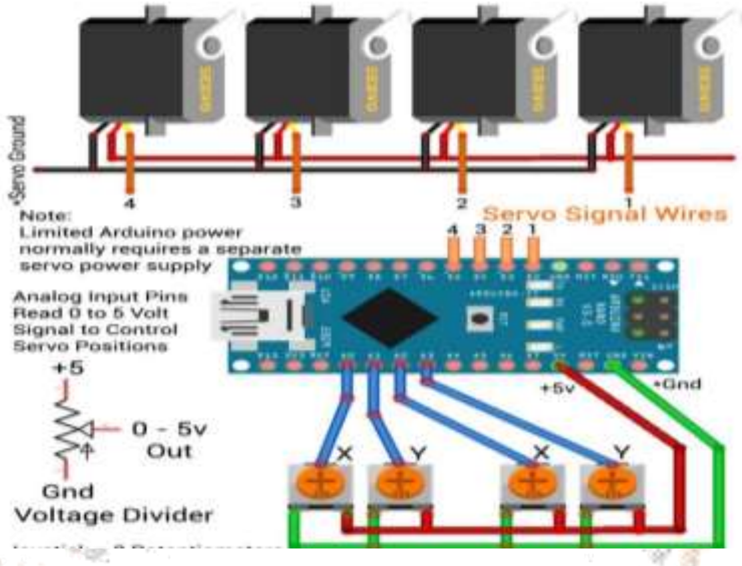
Fig 2.2 Single Tension Cable Design Proposal

3.CONSTRUCTION AND WORKING

The robotic hand is constructed with mechanical fingers or grippers that can articulate and move. Each finger or gripper is connected to an actuator, typically a servo motor, which provides the necessary motion. A potentiometer is incorporated into the system as an input device. It consists of a resistive track and a sliding contact known as the wiper. As the wiper moves along the resistive track, the resistance between the wiper and the other terminals changes. The robotic hand's movements are mapped to the potentiometer's position. For example, the potentiometer can be used to control the opening and closing of the hand or the flexion and extension of individual fingers. The specific mapping depends on the mechanical design and desired functionality of the robotic hand.

The potentiometer is connected to a microcontroller such as Arduino Nano. The three terminals of the potentiometer are wired as follows: one terminal is connected to the 6V power supply, another terminal to the ground (GND), and the wiper terminal to an analog input pin of the micro controller. The micro controller continuously reads the analog voltage value from the potentiometer through the analog input pin. The position of the wiper on the resistive track determines the analog voltage value. This value is converted into a digital representation that can be processed by the micro controller.

Before using the robotic hand, it is crucial to calibrate the potentiometer’s range of values to correspond to the desired range of hand movements.Calibration involves identifying the maximum and the minimum valuews of the potentiometer’s position and mapping them to the apopropriate range of motion for the hand. The analog voltage values obtained from the potentiometer are mapped to the calibrated range of motion or grip strength for the robotic hand. The microcontroller performs the necessary processing to scale and convert the analog values into usable commands for controlling the hand. The microcontroller sends control signals to the actuators (servo motors) based on the processed potentiometer values can be shown in figure3.1. These signals adjust the position, speed, or torque of the actuators, which in turn move the mechanical fingers or grippers of the robotic hand accordingly.By utilizing a potentiometer as an input device and integrating it with the control system of a robotic hand, users can manipulate the hand's movements and grasp objects with varying degrees of force, providing a more intuitive and interactive control experience.



3.1 Circuit Diagram

4. DESIGN OF ROBOTIC HAND

Designing the parts of a robotic hand in SolidWorks involves creating individual components that make up the hand, including fingers, joints, linkages, and a gripper mechanism. We have created a new part file in SolidWorks for each finger is shown in figure 4.1. By using sketches and features like extrude, revolve, or sweep we created the finger profile. Proper dimensions and relations are used to define the finger's size, shape, and proportions by consider incorporating joints or hinge mechanisms between finger segments for articulation. Further we desiged the joints and linkages that connect the fingers together and ensured that the joints provide the desired range of motion and allow for smooth movement between the fingers can be seen in figure 4.2 and 4.3. We also added necessary features like holes or slots for attaching the joints to the fingers.

We have also designed the gripper mechanism that allows the robotic hand to grasp objects. Gripper mechanism components, such as the base, fingers, and actuation mechanisms are individually designed. We have ensure that the gripper mechanism can exert sufficient force to grasp objects securely. Finally we create a new assembly file in SolidWorks to bring all the individual parts together. Using the assembly features in SolidWorks to mate the components together, ensuring proper alignment and movement. Further we tested the assembly by moving the fingers and verifying that the joints and linkages allow for the desired range of motion.

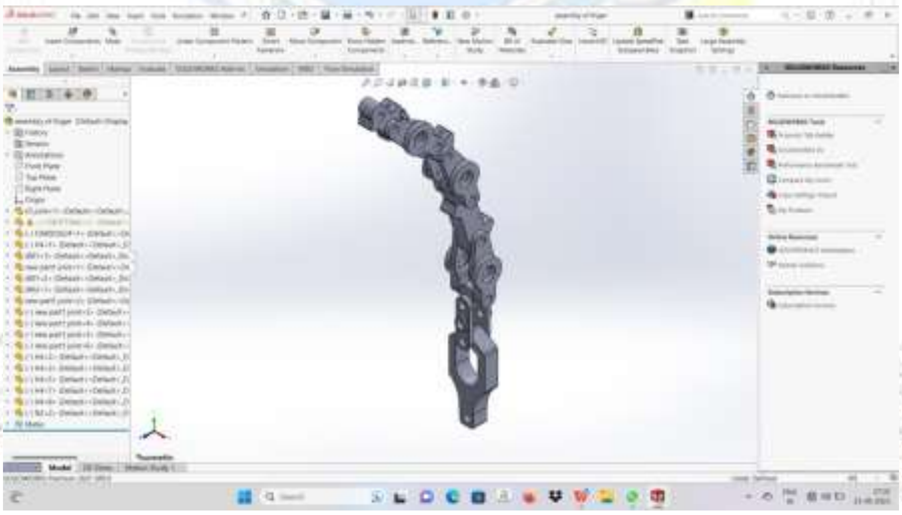


Fig 4.1 Model of Finger in Solid Works

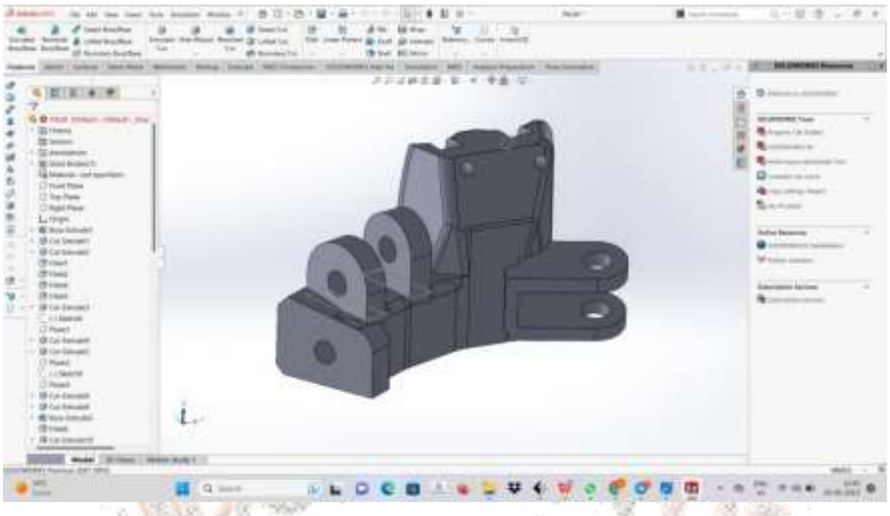


Fig 4.2 Model of Palm in Solid Works

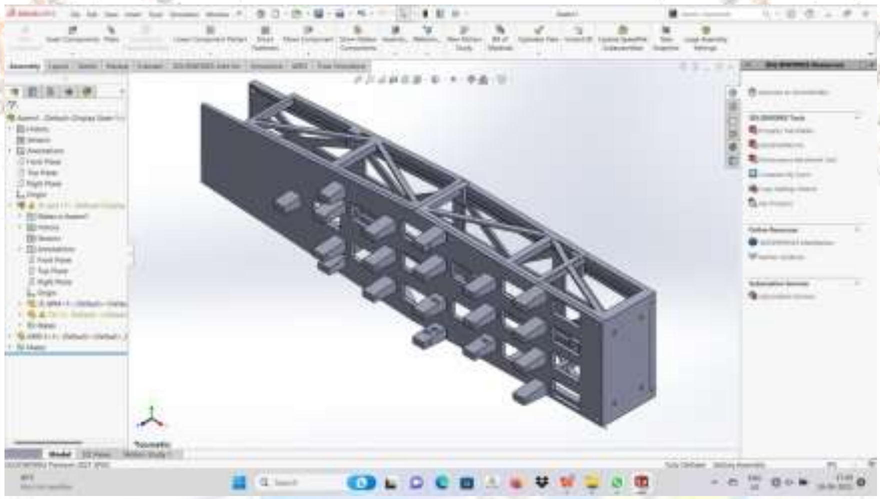


Fig 4.3 Model of Arm in Solid Works

5.FABRICATION

The parts of the robotic hand are fabricated using 3D printing technology. Conversion of .stl files into .gx files required a software called flash print. Flash Print is the software you can use with the Flash forge printers to get your 3D model ready for printing on an Flash forge printer. Flash Print allows you to slice your 3D models, this can be seen in figure 5.1. Once you slice a 3D model, you'll have a file that you can send to a 3D printer to print. For the Flash forge printers, you'll save a .stl file from Flash Print onto a USB stick and put that USB stick into the printer to access the file to print.By using 3D printing technology such as fused deposition method(FDM) the individual parts of robotic hand are 3D printed.The 3D printed parts of the finger are joined using M5 nuts and M3 screws. Further the fingers are joined to palm. Also the parts of the arm are joined together using M3 screws. Once all the 3D printed parts are joined together then servo motors like SG90 and MG 995 are fixed on to the arm .The strings are passed through the slots made in the fingers which further pass through the tubes and finally attached to the arms of servo motors.

The trimmer potentiometer sensors are fixed into slots of 3d printed parts of glove controller. The individual parts are assembled together in specified location using M3 screws. Figure 5.3 shows the arrangement of links with the glove. The signal wire servo motors are connected to digital pins of Arduino Nano and the signal wire of trimmer potentiometer sensors are connected to analog pins of Arduino Nano. Power to Arduino Nano is given by a 6 volt battery. The power to servo motors and trimmer potentiometer sensors is given by external power supply. Figure 5.2 and 5.4 shows partial and complete assembly of robotic hand.The entire setup for the project ran on two Arduino Nano for actuating movement in the robotic arm and measuring the bend of fingers and orientation of the wrist. All of the programming was written in C language in the Arduino IDE software.

Fig 5.1 Slice Preview of Palm Model

Fig 5.3 Assembly of glove

Fig 5.2 Partial assembly of robotic hand

Fig 5.4 Complete assembly of robotic hand

6.RESULTS

Each finger managed to contract individually, however some fingers performed better than others. An example of a digit with worse performance was the thumb on the robotic hand. Figures 6.1 and 6.2 shows the imitation of the wrists rotary movement was successful. As for the hand signs the robotic hand was able to replicate the hand signs carried out by the operator with the glove. Grip test of the robotic hand concluded that only objects with some give in them, that is to say soft to semi-soft objects, could be grasped. Objects of various shapes could be grasped but items of oblong cylindrical nature were the easiest to grip followed by lightweight spherical and rectangular objects last. This follows from the robotic hand only being able to perform a spherical valor grip due to its construction.

Fig 6.1 Result of the robotic hand imitation of the peace hand sign.

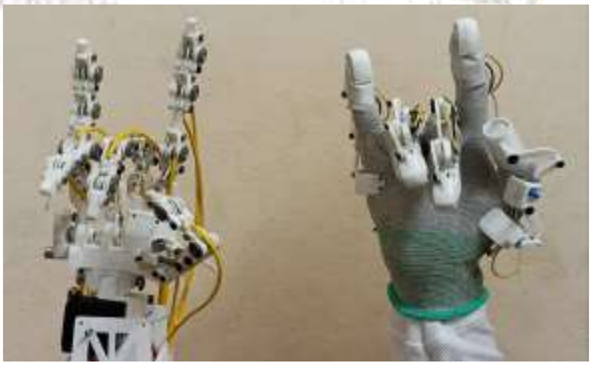


Fig 6.2 Result of the robotic hand imitation of the rock and roll hand sign.

7.CONCLUSION

In conclusion, the design and fabrication of a low-cost, 3D printed robotic hand is presented which was able to imitate the hand motions of the controller glove and grip objects.The mimicry of the motions from the controller was deemed to be good while the grip ability was deemed to be acceptable, leaving some areas for improvements. The controller glove the robotic hand was able to imitate the hand movements of the controller fairly well without any significant delay.The ability to grip objects was however limited to the weight and surface hardness of the objects. From the results it was observed that the robotic hand could grip surfaces that were soft or semi-soft.One improvement is to use more powerful and more precise servo motors and to employ more precise potentiometer sensors for better accuracy.

REFERENCES

[1] Carbone G., Iannone S., Gonzáles A.,Ceccarelli M., A Dynamic Simulation and Experimental Validation of a Three Finger Robotic Hand, ECCOMAS Thematic Conference Multibody Dynamics 2007, Milano, CD Proceedings, 20
[2] Design and Development of an Underactuated ProstheticHand .B.Massa ,S.Roccella ,M.C.Carrozza, P.Dario. International Conference on Robotic &Automation. Washington DC, May 2002.
[3] Mohammadi, A., Lavranos, J., Choong, P., Oetomo, D.: Grasp specific and user-friendly interface design for myoelectric hand prostheses.In: IEEE International Conference on Rehabilitation Robotics, ICORR, pp. 1621–1626 (2017).
[4] DEXMART Project (n.d.) DEXMART Project website. Available at: http://www.dexmart.eu/.
[5] R. J. Schwarz and C. Taylor, "The anatomy and mechanics of the human hand", Artificial limbs, vol. 2, no. 2, pp. 22–35, 1955.
[6]Arduino, What is arduino?, https : / / www . arduino . cc / en / guide / d 25-arch-2020].
[7] ——, Arduino Nano, https://store.arduino.cc/arduino-nano, [Online; accesses]
[8] M. Barr, "Pulse width modulation", Embedded Systems Programming, pp. 103–
104, 2001.
[9] TowerPro, MG996R Robot servo 180° Rotation, http : / / www . towerpro . com.tw/product/mg995- robot- servo- 180-rotation/, [Online; accessed 07-February-2020].