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Animatronic Robotic Hand Controlled by Glove Using Bluetooth

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***Abstract*— Research and development in the field of robotic hand has attracted a lot of attention recently. There are several applications for these automated tools. Thus, the main objective of the work of this project is to build a prototype of a robotic hand with a design similar to a human hand so that the robot hand is able to grasp objects of different sizes and weights, using a control glove consisting of five flexible sensors with wireless connection. Therefore, the robot hand is designed and built with 15 degrees of freedom fingers capable of applying independent forces on grip.**

To grasp objects and mimic the movements of a control glove worn by the user, the wireless communication capabilities of the robot's hand were tested. An Arduino Nano microprocessor, five flexible sensors, a Bluetooth transmitter, and an external power source were components of the control glove. The robotic hand is built from 3D-printed parts from an open source library, five servo motors, one for each finger, an Arduino Uno processor, a Bluetooth receiver, an external power supply, and other components. The result showed how effective the robotic hand is in simulating the operator's hand and its ability to pick up and manipulate different objects on different surfaces. This robot can be used in environments that are dangerous for people due to the reliability of wireless control and its ability to operate the robotic arm from a separate room.

Keywords*— *Robotic hand, bionic, Arduino, Bluetooth, teleoperation, flex sensors.

I. Introduction

Robotics are becoming more and more common in business and even in households, and their complexity is continually increasing. Robots are becoming more adaptable and lifelike because to advances in mechatronics that have produced sensors and actuators with extremely complex designs.

A robot hand is described as one that can perform an operation while imitating the actions of a human hand as shown in figure 1. In manufacturing and other applications that call for accuracy and dexterity, stable gripping and delicate manipulation with the multi-fingered robot hand are becoming more and more crucial as shown in figure 2. The majority of multi-fingered robotic hands utilized today are service robots, human-friendly robots, and personal robots.

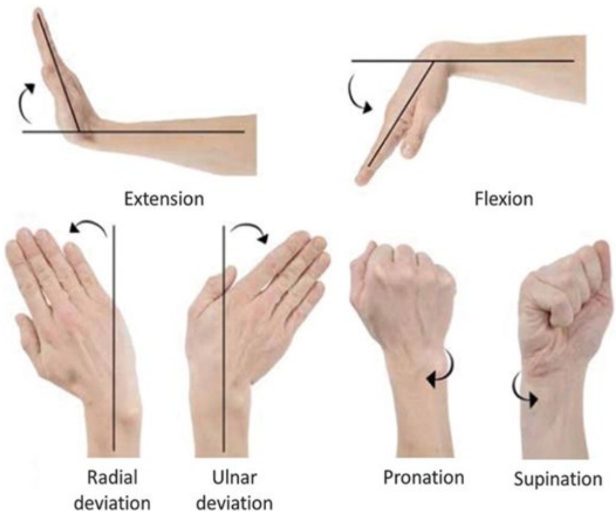

Fig. 1. Anatomy and Function of the wrist [3]

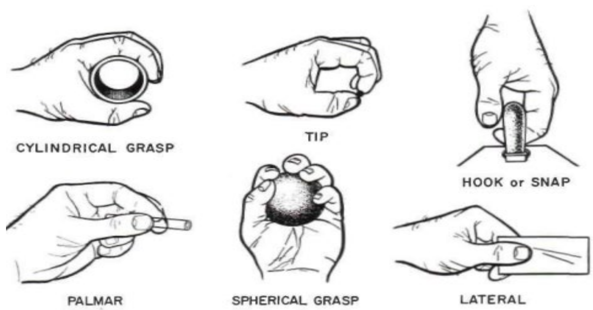

Fig. 2. Six basic types of prehension, as defined by Schlesinger [4]

Teleoperation is the process of remotely managing a robot or system so that a person and a robot may work together to complete tasks and reach a common objective. The system or robot being controlled is referred to as the teleoperator, whereas the operator is the human-controlling entity.

According to conventional literature, there are two types of teleoperation: direct teleoperation, in which the operator closes all control loops, and supervisory control, in which the teleoperator (a robot) demonstrates some level of control on its own [1].

In order for an operator to feel physically present at a remote location, the operator must get enough information about the teleoperator and the job environment and have it presented in a natural manner. In teleoperation, the more one feels present, the better one can perform a task.

By combining telecommunication systems with a second robot and growing group work robots to speed up the execution of the tasks and works, advanced research has been done to produce benefits to the robot industries.

Bluetooth technology is one form of communication system that may be integrated into the robot's peripheral.

Creating an anthropomorphic, dexterous, multi-finger robot that can accurately and precisely grip objects is challenging. The adaptability and sensitivity of the human hand are approximations. Different robotic hand kinds and applications are available today. Their economics, stability, and dependability are the most crucial factors to take into account.

The robot hand's primary features are different from those of a human hand. The cost is a factor in any robot hand mechanism. The most difficult challenge is to reduce the cost of the robot mechanism while maintaining its simplicity, which is identical to humans. As a result, this project will develop and fabricate a human hand, particularly for a master-slave Bluetooth communication network.

II. METHOD

The project was started through potential sketches as well as identifying the most important components of a robotic hand. A design adapted to the requirements was visualized with the help of a computer-aided design. A readily available design of the hand already existed online for public use. The rest of the robot was then designed to adapt to the hand. All parts were then created with the help of three-dimensional (3D) printers. Once this step was completed, the focus was on assembling all the parts that make up the robot with all the electronic components. Subsequently, the building of the code is started, the source code can be found in [9].

In addition, we worked on Mat Lab code that helped us choose the right material based on the application intended for the hand, source code see [9].

Finally, it is time to investigate the research questions, which were made with the help of two tests. The first test was performed by testing the grip function with six different grips. For the second test, the controller moved his hand at different speeds and checked how accurately the robot was able to imitate all the movements.

III. ELECTRICAL AND MECHANICAL COMPONENTS

The robotic hand will reflect the movements of the hand controller when it is being operated wirelessly by a person. As a result, the structure can be divided into two parts: one for the controller and the other for the robot hand itself.

A. *The Controller's Components*

The controller's finger movements must be tracked so that the robotic hand can simulate the movements using data collected by the flexible sensors (see Figure 3). Figure 4, shows the circuit of the components of the control unit.

a) Flex sensor: The bend sensor measures the degree of bending that occurs. The sensor is constructed from components like carbon and plastic. The flexible plastic sensor strip, which is a variable resistor whose terminal resistance rises as the sensor is bent, is put over the carbon surface. As a result, the sensor's resistance rises in proportion to the surface's linearity. In order to perceive changes in linearity, it is typically utilized [7, 8]. The elastic sensor, for instance, experiences a twofold increase in resistance when bent at a 45 degree angle. Additionally, the resistance might increase to four times the normal resistance when the curve is 90 degrees. Thus the resistance across the terminals rises linearly at a curvilinear angle. So, in a sense, the elastic sensor converts the elastic angle into an impedance parameter.

HC - 05 Bluetooth serial module: It is an easy-to-use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Its communication is via serial communication, which makes an easy way to interface with the controller or PC. HC-05 Bluetooth module provides a switching mode between master and slave mode, which means it, can use neither receiving nor transmitting [9].

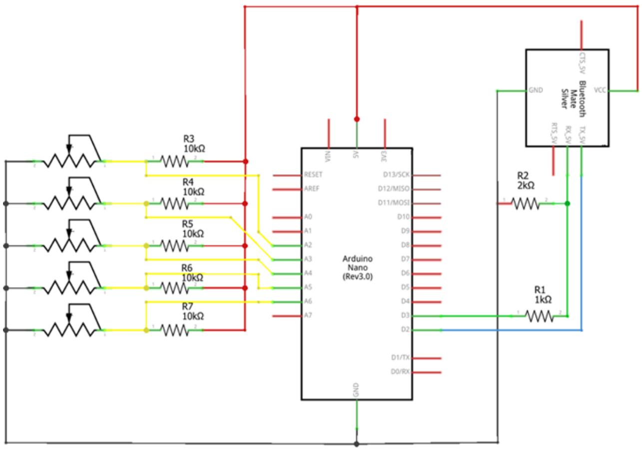

Fig. 3. Schematic diagram of the controller's components

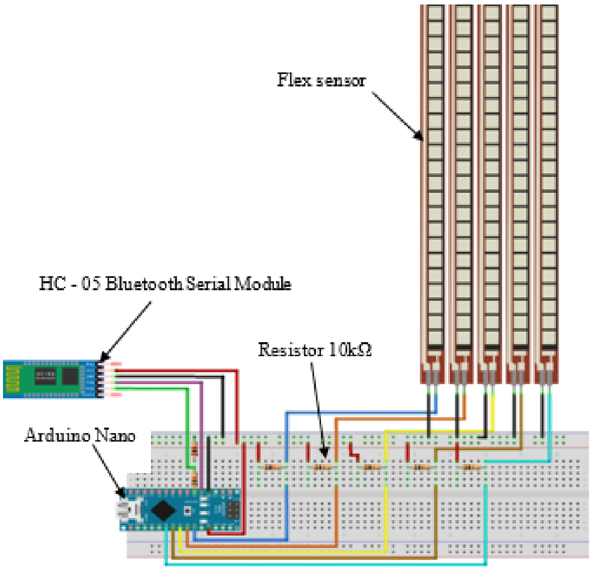

Fig. 4. The circuit of the controller's components

b) Arduino Nano: Arduino Nano is made by Arduino (open source software and hardware company), and it is a type of microcontroller board. It could be built using an Atmega328 microprocessor. It is a flexible and compact board that has various uses. Since it lacks a direct current (DC) connector, the power supply can be supplied via a micro USB port instead of connecting directly to pins such as VCC and GND. Using a micro USB connection on the board, 6 to 20 volts can be supplied to this board.

B. The Robotic Hand's Components

The data read from the control unit is converted by the robotic hand into the number of degrees the motor shaft should rotate. The components needed for a robot hand to move its fingers are listed in Figure 5 and the table I.

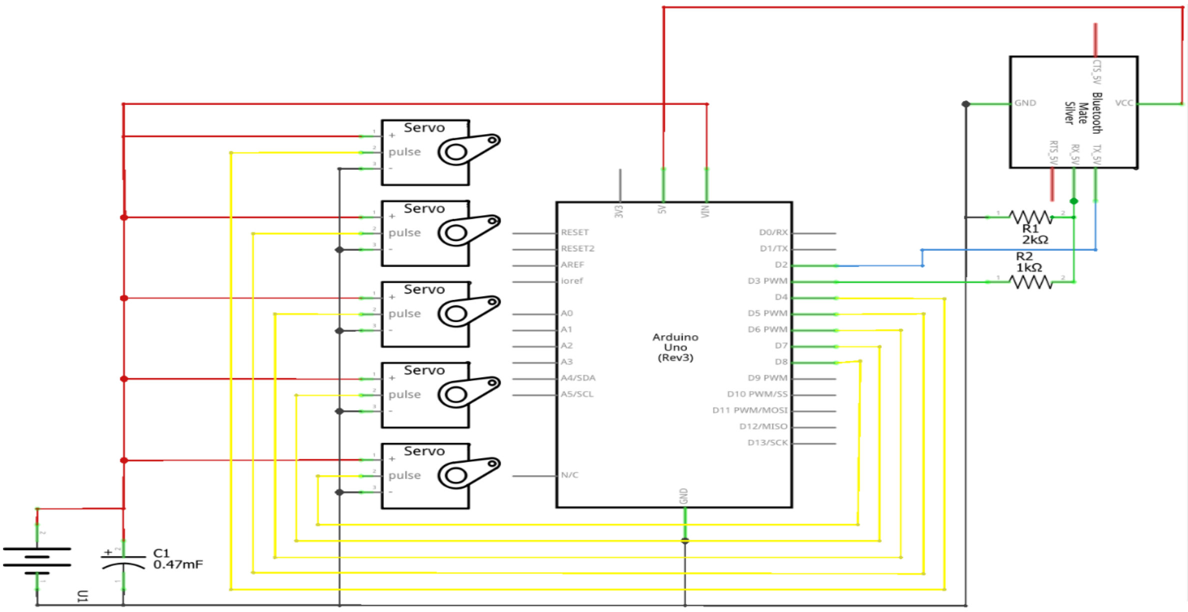

Fig. 5. Schematic diagram of the robotic hand's components

TABLE I. THE COMPONENTS NEEDED FOR A ROBOT HAND TO MOVE ITS FINGERS

Component	**Amount**
Arduino Uno	1
MG996r Servo Motor	5
HC - 05 Bluetooth Serial Module	1
5v Electrical transformer	1

The Arduino Uno translates the data after being received by the HC-05 Bluetooth Serial Module. Afterward, an MG996r servomotor controls each finger individually. due to the hand's weight. The motors must run at high torques, which necessitates high voltages for each motor. So, a 5-volt electrical transformer is selected, see the source code to control the Hand controller can be found in [9].

a) Servo Motor: A metal gear servo motor with a maximum stall torque of 11 kg/cm is named the MG996R. The motor rotates from 0 to 180 degrees like other RC servos based on the duty cycle of the Pulse-width Modulation (PWM) wave given to its signal. pin.With a redesigned printed circuit board and integrated circuit control, system that makes it is much more accurate than its predecessor. The gearing and motor have also been upgraded to improve dead bandwidth and centering. Since motors with feedback are referred to as servomotors together, there are several varieties of servomotors available for various purposes. All servomotors have the same basic design, which entails a potentiometer coupled to a control circuit and either an alternating current (AC) or direct current (DC) motor. Being a feedback system, the movement of the motor causes the potentiometer to rotate, and as it does, its resistance produces a signal in the form of a voltage, which is then compared to the input voltage. This makes it very simple to regulate how many degrees the motor axle has turned. Electrical pulses, also known as pulse width modulation, are used to operate servomotors (PWM). The control signal typically occurs at a frequency of 50 Hertz, or once every 20 milliseconds (ms) (Hz). The servomotor's location is determined by the pulse's duration. While pulses of 1.5 and 2 ms often equate to 90° and 180°, respectively, and pulses of 1 ms typically correspond to 0°. Figure 6, shows how PWM influences the position of the servomotor.

b) Arduino UNO: This extremely useful addition to electronics has an Atmega328 microcontroller, a USB interface, 14 digital I/O pins (of which 6 Pins are utilized for PWM), and 6 analog pins. Additionally, it supports the Serial, and SPI (Serial Peripheral Interface) protocols [6, 7, 8, 11].

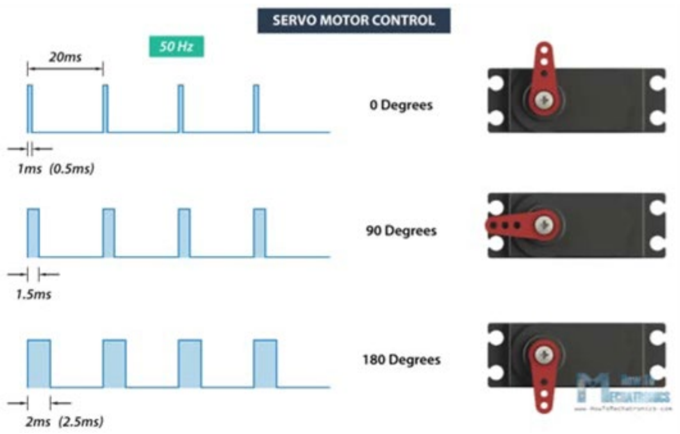

Fig. 6. Correlation between PWM and angle [5]

IV. DESIGN AND ASSEMBLY

A. Design of the Robotic Hand

The robot's hand consists of two main components, the hand and the forearm, each made up of smaller. A screw is also inserted between each joint to mimic the joint between each part from the finger.

With the help of a thin rope and an elastic band, the fingers are stretched and extracted in such a way as to reflect the movement of the muscles in the body. Each component has two smaller holes - one for the rope that compresses the finger and the other for the rubber band that returns the finger to its normal position, see Figure 7.

The wrist, elbow, and tube that make up the forearm are all 3D printed as part of the forearm. The tube contains a hole sized to fit a motor holder where the motors pulling the fingers are installed as shown in Figure 8.

B. Design of the Controller

The glove with five flex sensors served as the primary controller for the robotic hand. One flex sensor was responsible for controlling each finger on the robotic hand. The glove's flex sensors were fastened to it, and an Arduino Nano was linked to it using a breadboard. Both hand extension and flexion were accomplished by mapping the changing resistance of the flex sensors to a degree of rotation in the servo motors (see figure 9 and 10).

The HC-05 Bluetooth Serial Module was connected to the Arduino Nano to make the controller glove wireless. The controller glove's Arduino Nano was powered by an external power supply (see figure 9 and 10).

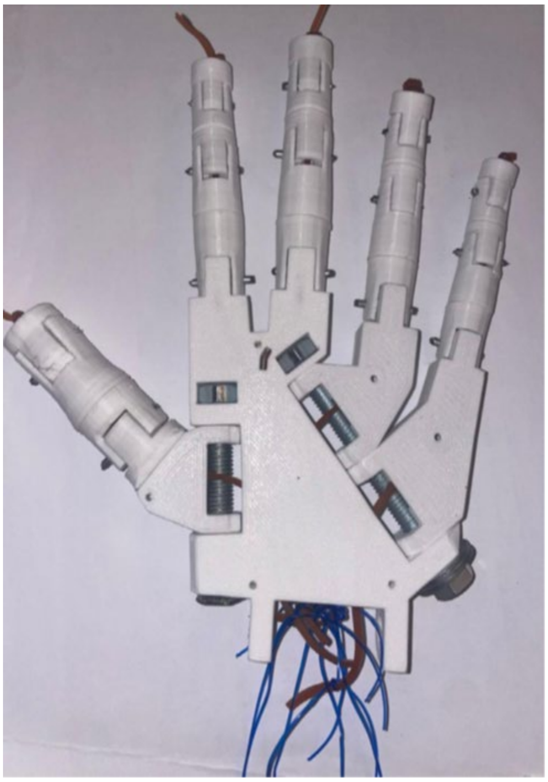

Fig. 7. Hand assembly (made up using 3D printer)

Fig. 8. Arm and servo assembly (made up using 3D printer)

V. RESULTS

- The test results demonstrate that the robotic hand successfully and with minimally apparent lag simulates the operator's hand at every joint. We used servomotors because, unless the hand was holding a heavy object, they could accurately replicate joint rotations. The inaccuracy in moving a weight is most likely caused by the weak motors.

- The servomotor was unsteady because there was a lot of signal noise, which we were able to minimize with a capacitor. The noise was still audible, but with a more reliable power source and an effective servomotor, it could be controlled.

- The operator was able to control the robotic hand from a different room thanks to the transmitters. The largest distance that could be successfully covered with obstacles like walls and barriers in the way was about 7 meters. The transmitter states that there are no impediments within 10 meters and that the data transfer rate can vary up to 1Mbps.

- The hand could lift weights up to 10 grams, and the claw could grasp objects with a range of shapes and surfaces.

Discussion:

The robotic hand was quite good at mimicking the operating arm. It moved simultaneously with the operator. Servomotors are not particularly powerful, and since the feedback is internal, they occasionally start shaking.

As we already know, there are several uses for our project, thus the material we choose to construct the hand will depend on those uses. The eight typical 3D printer filaments are Engineering PLA (Polylactic acid), ABS (acrylonitrile-butadiene-styrene), PETG (Polyethylene terephthalate glycol), nylon, a composite made of PETG and carbon fiber, PVA (Polyvinyl Alcohol), HIPS (High Impact Polystyrene), Flexible filament (TPU), and Polypropylene. The application determines which 3D printing material is ideal, and each 3D printing material has benefits and cons of its own. The Bolt Pro 3D printer has a lot going for it. It includes two separate extruders (IDEX). As a result, users can choose to combine two materials to utilize one as a support or to employ several shades of the same material to produce distinctive models. When attempting to mix two distinct types of filaments, the specific material qualities of each 3D printing material become more crucial. Characteristics of each type of filament for 3D printers as listed in [9].

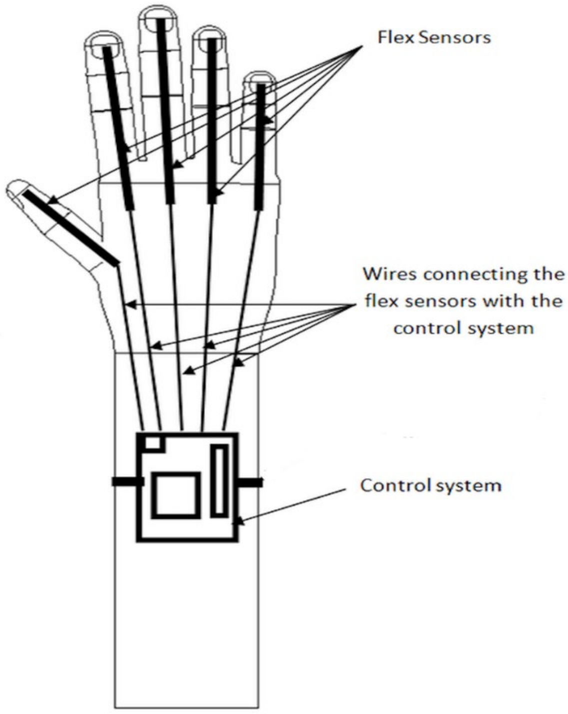

Fig. 9. Schematic diagram of controller system

Fig. 10. Robotic hand controlled by glove using Bluetooth

VI. CONCLUSION AND FUTURE WORK

- Conclusion:

Robotic hands with remote control capabilities have been built as a prototype. For the prototype, the precision was favorably received and the prototype was able to accomplish the majority of fundamental grasping methods. The weight of the building and the base's stiffness were the main determinants of accuracy. Despite certain restrictions, all of the study questions had favorable replies. Although the motions were quite effective, there are still some things that may be done better. although it could be taken off. With the controller connected, mobility is challenging and restricted. Additionally, the robotic hand might be strengthened and made larger.

The capability to record and repeat actions might be added to the robotic arm, enabling the user to quickly automate repetitive activities. This might be done quite simply by recording all angles in a vector or matrix, shifting the servos to the recorded angles during execution by iteratively traversing over the vector. A button or other signal to start and stop recording is all that is required to enable this feature.

- Future work:

The project has a lot of promise, and with the suggestions that can be done, a more durable design that allows for even more DOF with better accuracy may be developed.

- Due to economic constraints, the hand model utilized in this project is quite simple to use. One might consider more intricate designs for a larger range of grasping methods. Examining 3D-printed hand screws would be an additional enhancement for the hand. This will enable a considerable reduction in the construction's weight.
- Additionally, we have access to more effective wireless communication systems with a wider coverage area and low signal noise.
- Our original goal for the project was for the upper arm to be able to rotate as well, however, owing to financial constraints this was not possible.
- Modifying this project to match the prosthetics program and controlling it by attaching it to nerve sensors is one of the forthcoming jobs that has to be finished.

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