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HAPTIC CONTROLLED ROBOTIC ARM

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Abstract— **Robotics is one of the foremost fields in engineering with a massive escalation over the past few decades. It focuses on the modeling, assembly and functioning of robots. Robotic arms in present-day market lack the efficiency to carry out highly precise controlling operations. By using Haptic technology, the errors in the operation of the robotic arm can be reduced. A particular state or condition of the device or the robot is bound to a specific haptic gesture. The proposed robotic arm is controlled by the human hand. Flex sensors are used to sense the finger movements. This information is transmitted to the robotic arm which moves accordingly.**

Index Terms— **Haptic technology, Haptic gesture, Flex sensors**

I.INTRODUCTION

A robotic arm is a mechanical structure used to replicate the actions of human limbs. Robotic Arms are widely used nowadays as an individual mechanism or as a part of a complex robotic system. They are used for pick and place work in industries and warehouses. They are also used in bomb disposal robots to render safe the explosives. Robotic arms also play a major role in 'search-and-rescue' robots used at the time of mining accidents, urban disasters, etc. These robotic arms are generally designed as a Two Jaw Grippers. These are servo operated structures. The two jaws are controlled by a servo whose rotation angle can be changed to close or open the jaws [1]. They are easy to operate, low cost & widely used by electronics hobbyists. However, they cannot mimic the flexibility of human hand and have limited degree of freedom.

This paper focuses on designing and implementing a robotic arm. It goes beyond the traditional way of controlling the robotic arm using buttons and joysticks, and substitutes it with a more advanced approach of using human hand movements for the purpose. This gives the user a realistic experience of grasping the object, and improves his decision-making abilities. The proposed work is a device that replicates the operator's hand movements and also recognizes the sensor information, processes it and utilizes it to carry out the desired action by giving necessary commands to the actuators. It is made up of several sections which are bound collectively by linkages. The robotic arm is provided with X degrees of freedom.

Haptics enhances the user experience through improved usability, enhanced realism, and restoration of mechanical feel [2]. The proposed work focuses on design and assembly of Robotic Arm and controlling it using a haptic glove.

II.HARDWARE COMPONENTS

The proposed project work requires hardware components like micro controller, flex sensors, inertial measurement unit, servo motors.

A. Arduino Mega 2560

It is a simple i/o board. It is used to create stand-alone systems. It is based on the ATmega2560. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. The Mega2560 differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the ATmega16U2 (ATmega8U2 in the revision 1 and revision 2 boards) programmed as a USB-to-serial converter [3].

B. Flex Sensors

Flex sensors are also called bend sensors. They measure the amount of deflection caused by bending the sensor. There are various ways of sensing deflection, from strain-gauges to hall-effect sensors. Each finger on the haptic glove is fitted with a flex sensor. Each flex sensor is 4.5" in length (except for little finger, 2.2" in length).As the sensor bends, the resistance across the sensor changes. The resistance increases with increase in angular bend. The resistance of the flex sensor varies only when the metal pads are on the outside of the bend. Unbent it measures about 10KΩ, to 20KΩ when bend 180º. [4][5].

C. Inertial Measurement Unit

The IMU is an electronic device which collects data about linear and angular motion by calculating linear velocity and angular acceleration. It measures velocity and orientation of the arm using combination of accelerometer and gyroscope. The accelerometer is used to detect change in rate of acceleration and the tilt while the gyroscope is used to measure the angular velocity and to detect the change in rotational attributes like pitch (up and down) , yaw (left and right), and roll (clockwise and anticlockwise) [6]. The IMU is used for control, stabilization and efficient operation of the robotic arm.

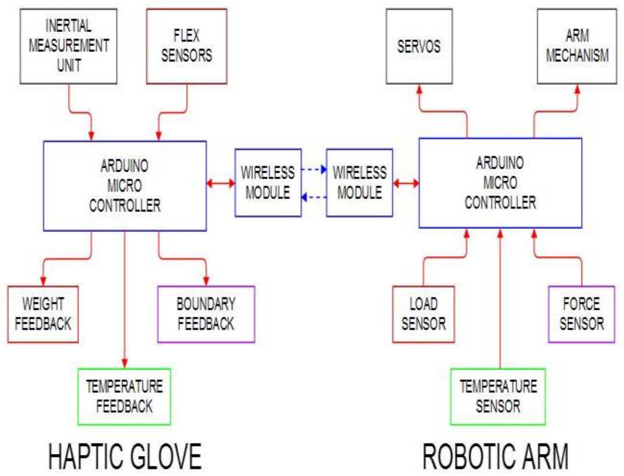
D. Servo Motors

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servos are controlled by sending an electrical pulse of variable width (PWM), through the control wire. There is a minimum pulse, a maximum pulse and a repetition rate. A servo motor can usually only turn 90° in either direction for a total of 180° movement. The motor's neutral position is defined as the position where the servo has the same amount of potential rotation in the both the clockwise or counter-clockwise direction. The PWM sent to the motor determines position of the shaft, and based on the duration of the pulse sent via the control wire the rotor will turn to the desired position [7].

III.SOFTWARE USED

Arduino software or the Arduino IDE is an integrated development environment which is used to program Arduino Micro Controllers. It is open source software and a cross-platform application. The syntax used is C language. The software makes it easy to write a code (called as 'sketch') using code editor, compile (to verify and check for errors) and upload the code on the board. Some libraries are included with the Arduino software. These libraries provide extra functionality for use in the sketches. The exchange of data with the board on the currently selected port can be done using Serial Monitor window [8].

IV.DESIGN AND IMPLEMENTATION



The project implementation takes place in following stages:

V.HAPTIC GLOVE

The haptic glove fits on the human hand. It is used to track the motion of human arm as also movement of fingers. Five flex sensors are used to track the movement of the fingers. An inertial measurement unit will be used to sense the motion of the human arm. A movement restricting mechanism will be designed to restrict the motion of human hand once the force exerted by the robotic hand exceeds the threshold limit.

A. Initial Design

A prototype glove is designed by using a rubber glove. A flex sensor is fitted on each of the finger of the glove. To protect the flex sensors, and to aid their bending according to movement of human fingers, the flex sensors are inserted into sleeve tubes. The five sleeve tubes containing flex sensors are then glued onto the rubber glove.
Disadvantage: The rubber glove is less durable. Proper bending of flex sensors is not achieved.

Fig.1. Haptic Glove (Initial Design).

B. Final Design

A durable, good quality woolen glove is used. Sleeves for flex sensors are stitched on each finger. The flex sensors are covered by the sleeves. This provides protection to the flex sensors from external abrasion. The flex sensors are stitched onto the glove for assisting efficient bending along with human finger movements.

Fig.2. Haptic Glove (Final Design).

VI.ROBOTIC ARM

The robotic arm is an electro- mechanical device consisting of arm & hand part. The hand consists of 5 movable fingers. They are controlled individually by servos. The servos are controlled by signals from the flex sensors fitted on haptic glove which track the finger movements. The arm will be controlled by the IMU signals and can mimic human arm movement in vertical and sideways directions (2 DOF).

A. Initial Design

The prototype robotic arm is fabricated using flexible pipes as fingers. Individual servos are used to control each finger by pulling it with a thread. The servo rotation is proportional to the bending of human fingers (flex sensors), measured on the haptic glove.

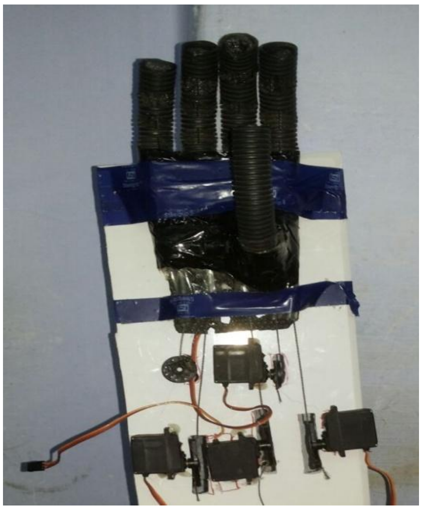


Fig.3. Robotic Arm (Initial Design).

B. Final Design

The final design is a more rigid robotic hand, made of PLA. The 3D printed plastic parts function as bones. The servo motors function as muscles. And, the filaments function as tendons. This is to make the robotic hand similar to human hand.

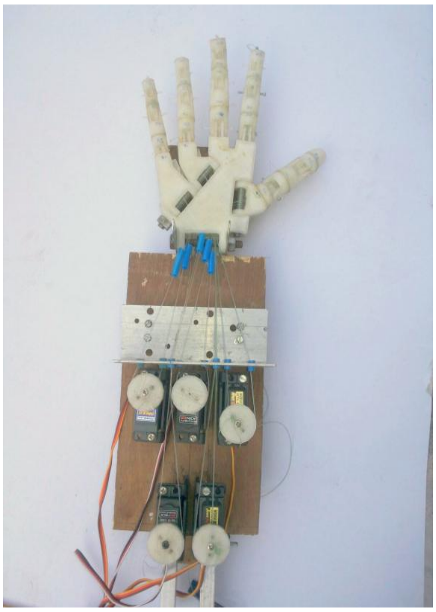


Fig.4. Robotic Arm (Final Design).

VII.FUTURE WORK

The robotic arm has to be provided with 2 DOF to improve its ability to mimic the human arm movements. The robotic arm should be able to sense the temperature of the object it is holding. It should also be able to gauge the grip on the object. This feedback data collected should be transferred to the haptic glove for making user experience more informative.

VIII.CONCLUSIONS

The synopsis thus emphasizes on obtaining all the necessary sensory information about the target object by mounting various sensors on the robotic arm and providing relevant feedback to the human hand for improving the user's action.

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