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Flex Sensors Controlled Animatronics Hand

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Abstract: This paper focuses on understanding the simple and unique technique that is used for human robot interaction in robotic hand gesture replication system. The aims to fabricate a dual module system which synchronizes the real hand gesture with mechanical movement of the designed hand module at the output end in real time. The first part input module (IM) is user-controlled module which detects the real hand movement and convert it into signals and the signals are transmitted wirelessly to a receiver module comprising of a mechanical animatronics hand that will process the incoming signals and performs the mechanical movement in coherence with the received signal. Arduino boards integrated with their own microcontrollers and Xbee antennas are used to control both the input and output modules for the completion of the perform gesture. The input module comprises of a glove integrated with flex sensors and the Arduino board. 3D structure which is modeled as the real hand with the servo motors installed on it is used as an output module for the replication of the generated gesture from input module. This paper describes that advantages of Flex Sensors Controlled Animatronics Hand are in the environment which obstructs the physical approach of the humans and is not feasible for the human body. Nuclear power plants or nuclear weapon production areas, sophisticated chemical or pharmaceutical factories, bomb disposal department and Firefighting agencies etc. In all of these scenarios, Personal control is essential yet environment restricts the physical presence of human, therefore, this technique can be used as an alternative to automation so that an individual can operate under such conditions without physically being present at the location, preventing any unforeseen accidents and human casualties.

***Keywords**: Flex Sensors, Servo Motors, Animatronics Hand Gesture Replication System (AHGRS), Arduino, Programming of the Arduino PCB.*

1. INTRODUCTION

In the 21st century, one of the defining technologies that have been a subject of continuous innovation is automation and artificial intelligence. The aforesaid field of study has a huge

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potential in the terms of industrial and scientific applications and it may even extend to a commercial use in the future time where the thought of having a robotic apprentice is within mankind's intellectual reaches. In this paper theoretical knowledge to develop optimized practical approach in order to make useful papers using embedded systems. However, despite all these potential benefits, there are still some key areas of interest where absolute human control is essential and cannot be relied on automation to carry on the task or take the risk. In light of this, the paper F.S.C.A.H (flex sensors-controlled animatronics hand) provides an alternative to automation in applications that require a human operator. In respect to this paper component selection, we have different variety of board which we can use in our paper which includes Raspberry-Pie, Texas instrument, Arduino but as we know Arduino is considered as the most feasible embedded system for this paper because it is more flexible and more optimized and have more commercial worth than other embedded systems. The problem for which we designed a Flex Sensors Controlled Animatronics hand is used in the environment in which obstructs the physical approach of the humans and is not feasible for the human body. This paper can be used as an alternative to automation so that an individual can operate under such conditions without physically being present at the location, preventing any unforeseen accidents and human casualties. Purpose and Goals of this paper is operating our hand by using flex sensor and gloves or we can say design a cost-effective glove integrated with the flex sensors in order to operate the robotic hand remotely. Many researchers have been done, many paper and thesis has been presented. This hand has batter result and precision level. We will able to get following goals by using (F.S.C.A.H).

2. METHODOLOGY

To overcome the above given problem, we use a best method. Flex sensors-controlled animatronics hand (F.S.C.A.H) is a better solution than the other solutions because it's not only made for one problem it is designed to overcome many problems which discussed above. The method which we use in this paper is that we designed a 3D printed hand has two modules

- **a)** Input module (IM)
- **b)** Output module (OM)

Input module consists of hand, controller and an Xbee (transmitter). The hand has 4 fingers and a thumb which are connected to SM (servo motors). We also made a glove on which flex sensor are attached we use 5 flex sensor that measure the change in the resistance the hand and the glove are connected through Xbee (receiver). This is an output module. We use Arduino for programming because it's easy to use. Then we also have voltage divider circuit. As we move our glove the resistance will be changed and information will go to the transmitter. On output module, there is a receiver which receives the information and this information than goes to the hand by using Arduino. This is a simple technique which we used to operate our hand.

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Fig.1.Simple block diagram

Hardware Description

F.S.C.A.H is a two-module system in which the input module is user controlled where finger movement are sensed and then transmitted wirelessly to a remote receiver on the Output Module comprising of an animatronics hand that will interpret the incoming signals and replicate the gestures in real-time.

Both the modules are controlled by separate Arduino boards integrated with their own microcontrollers and xbee Antennas to fulfill the tasks. The output hand is composed of 3D printed hand attached with servo motors for movement of the fingers. The input module consists of a glove integrated with flex sensors and the Arduino board.

a) Arduino is some open-source electronics prototyping platform. Fig.2. It is based on flexible hardware and software. It's the motherboard on which Atmega328 microcontroller attached whereas Atmega328 Microcontroller is the real component. And that performs decision making in a specific task. The Board provides supports integration with Zigbee or Xbee antennas, sensors and external circuitry to enhance functionality.

Fig.2. Arduino Board

It is open-source, software/hardware is extremely accessible and it is very flexible to be customized. It is flexible, offers a variety of digital inputs, analog inputs and Serial Peripheral Interface. It is inexpensive and this correlates with the one of the major goals behind our paper of creating a cost-effective solution to automation.

b) Flex sensors are sensors that change in resistance depending on the amount of bend in the sensor. They convert the change in bend to electrical resistance- As you increase the bend the resistance will change accordingly. They are usually come in many forms and they are thin strip from 1"-5" long. As shown in fig.3.

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Fig.3. Flex sensor

Flex sensors (FS) are analog resistors. They always work as variable analog voltage dividers. Inside of the flex sensor there are carbon resistive elements within an thin flexible substrate. Less carbon means high resistance. When any substrate is bent the sensor produces a resistance output that is relative to the bend radius. As shown in fig (4).

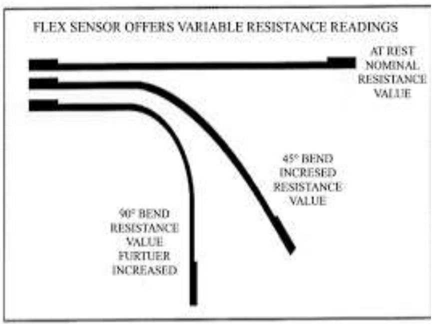

Fig4. Flex sensor working

For the purpose of our paper, we choose 4.5” flex sensors mainly because of two reasons. Firstly the 4.5” flex sensors are long enough to cover the area of any finger and secondly, they are easily available.

a) Zigbee is a device that is specific for a high

level communication protocols used to create a personal network built low-power digital radios. This device (ZigBee) is based on IEEE 802.15 standard. Because of low-powered, this device can send all data over long distances by passing data through ID (intermediate devices) to reach more distant ones, to create a mesh network like high-power transmitter/receiver (T/R) able to reach all of the networked devices. The decentralized nature of such devices and hoc networks makes them suitable and useful for applications where a central node can't be relied upon. ZigBee is used in different applications that require only small data rate, long life of battery, and secure networking. It has defined rate of 255 Kbit/s, which is very much suited for periodic signal or input device (ID). Applications include wireless light switches, electrical meters using in the houses, traffic control systems, and other consumer and high equipment that requires small-range wireless transfer of data at relatively low rates. The technology which is providing by the ZigBee is simpler and not expensive than other WPANs, such as Wi-Fi. ZigBee is a low-cost, low-power device with wireless mesh network standard. The low cost of ZigBee allows the technology to be widely deployed in wireless control and the other monitoring applications. Because of its Low power usage, it allows longer life with smaller

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batteries. Mesh networking provides very high reliability and much extensive range which is also a main reason to use it widely.

Fig.5. Xbee

ZigBee chip vendors typically sell microcontrollers with between 65 KB and 256 KB flash memory.
For the purpose of our paper, we choose XBee 1mW wireless antennas (ZigBee modules) because of the reason that they can be easily integrated with Arduino microcontroller with the help of Arduino shield, using them ensures secure and error free data transmission and they are easily available at a reasonable price.

b) A servomotor is a rotary actuator that permit
for precise control of the angular position, angular velocity and acceleration of any body. It always consists of a suitable motor that are coupled to a sensor for position feedback. It also requires a slightly sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are widely using in such a given application like robotics, machinery or automated manufacturing.

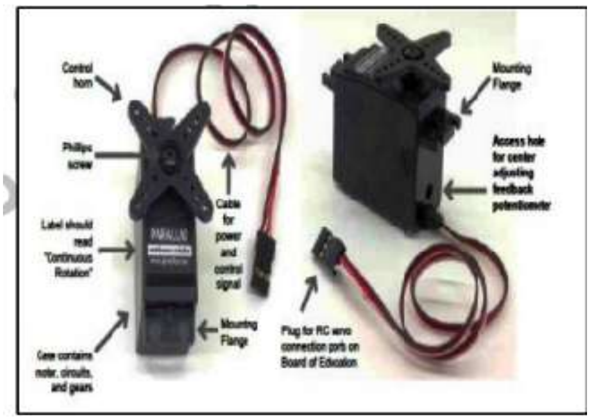

Fig.6. Servo motors

Servos are restrained by sending an electrical pulse of variable width, or pulse width modulation (PWM), through the control wire. There is a minimum pulse (MiP), a maximum pulse (MaP), and a repetition rate. Servo motors can turn only 90 degrees in either direction(way) for a total of the 180-degree movement**.**

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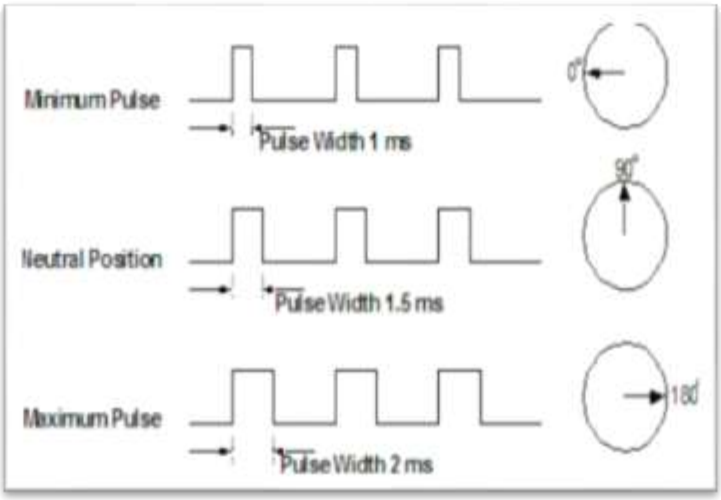

Fig.7. Working of SM

The neutral position of the SM is defined as the position where in the both the clockwise or counter-clockwise direction the servo has the complex objects. The actuation same amount of potential rotation. The PWM sent to the motor so that we can determines position of the shaft, and it based on duration of the pulse signal sent via the control wire, the rotor will turn to the required position. The SM expects to see a pulse within every 20 milliseconds (ms) and the given length of the pulse will determine how much or far the motor will turns.

Let's see an example; a 1.5ms pulse should make the motor turn to exact 90-degree position. Pulse which is less than 1.5ms moves it to the 0 degrees and any pulse longer than 1.5ms definitely turn the servo to 180 degrees. When these servos commanded to turn by code, they will move and hold that position. If an external force pushes the servo when the servo is holding a position, the servo will not move from position. The amount of force that a servo can exert is called torque rating of servo. servos will not hold their position all time (forever) though, the position pulse must be repeated to instruct the servo to stay in position.

For the purpose of the paper Tower Pro Mg996R servomotors were chosen because of the fact that at 4.8V it produces a torque of 10 kg-cm which is sufficient to control fingers of the robotic hand, secondly it has metal gear types and is smaller in size.

c) Design And Construction Process

The guidelines for the hands discussed above enable the construction of a multi-fingered anthropomorphic robot hand which is able to imitate the rudimentary movements and gestures of a biological hand especially in handling mechanism comprises of servo motors, pulling strings and elastic spring that are connected to the finger joints and thus promote inward curling and outward extending of the fingers. Figure 4.1 is below

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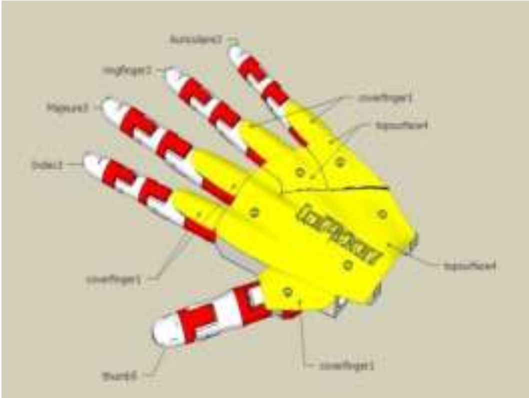

Fig.8**.**Basic Design Of Hand

In the Fabrication technique first preference in regards to the material for the hand to be fabricated and mass manufactured was a polymer based hand. The hand was to be designed in CAD software such as ProE and then converted to. STL file format which is the file type associated with 3-d printing.

3-d printing offered a feasible technique for fabricating the animatronics hand components since it assures quality of the parts produced as well as retains the accurate dimensions of the hand designed. In addition to this, the output of the 3d printing is polymer based hence it also encourages mass manufacturing of the components for future applications. The plastic commonly used in 3d printing is ABS Plastic which is used as the filament in a 3d printer being melted and drawn layer by layer in accordance with the. STL file of the design.

However, this approach has a few shortcomings with regards to the availability of 3d printing services in Pakistan at present. The vendors offering such services are very few in numbers and the price demanded to manufacture 3d printed components is overinflated at the moment. This is particularly due to 3-d printing being relatively new in commercial markets. The price of the printed components is evaluated based on the total volume of the parts produced which in the case of F.S.C.A.H comprising of about 75 separate parts was humungous and against the primary objective of providing a cost-effective paper.

Institutes such as Government College of Technology TAVTA (Taxila) own similar printing machinery to the Modern 3-d Printer called Mass Rapid Prototyping Machine (MRP Machines). RP is an advanced technique which utilizes automated fabrication of physical model or prototype from computerized data or CAD system for visualization, testing and verification. It works by forming desired shape by adding or removing layers of material. There are several RP techniques that can be used to produce this finger prototype. These machines employ PLA polymer as the material used in prototyping and have a similar working mechanism to that of modern 3d printers. However, there are certain demerits and problems that were encountered pertaining to the usage of MRP machines. We designed this hand from Karachi. When we receive this hand, it was divided up to 50 pieces.

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Fig. 9. Components of 3D Printed Hand

d) Finger Actuator and Mechanism

This robotic hand deploys five TowerPro MG996R servo motors which provide a torque of 10 kg.cm and rotation in a range of 0 to 180 degrees. An output circuit has been implemented comprising of Arduino board and the Xbee Receiver module to receive the input signals and manipulate it in the microcontroller to regulate the movement. This regulation is done via Pulse Width Modulation (PWM) by supplying an appropriate signal to the input. The frequency of this signal has to be 40 Hz which converting into timescale represents a time period of 25ms. Depending on the pulse width of the high gauge in a period the motor will turn. The range of the pulse width has to be between 0.5ms – 2.5ms, whereas a pulse of 0.5ms causes a rotation to 0°. Hence a high time of 2.5ms drives the motor to 180°. By applying a signal with at a high pulse in the requested range and with the required frequency, it is feasible to reach every angle between 0° - 180°. Therefore, the signal received at the output circuit is modulated in accordance with the value on the flex sensor and this generates a rotary motion of the servos from 0 to 180 degrees based upon the magnitude of the flex sensor signal.

Fig.10**.** 3D Design of Hand After Assemble

An additional servo mounted on the sleeve of the arm. These two parts merged to form an arm to support the animatronics hand. An additional servo bed was constructed to accommodate the five servo motors used along with an Arduino board support mounted on the sleeve of the arm. These two parts merged to form an arm to support the animatronics hand

e) Future Enhancement

Adding Haptic Feedback to provide touch sensation. This could be accomplished by using FSRs (Force Sensing Resistors) on the animatronics hand and Linear Resonant

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Actuator Vibrator on the input glove. Adding Visual Capabilities by integrating a portable camera along with the output module so that the user can also receive visual information. Integrating forearm and Wrist rotation to enhance mobility with the help of additional Servo motors. Installing a mobile platform for the hand to transport the output module to a specified location. Two-hand System for improved functionality. Possible biomedical applications: Prosthetic limbs if upgraded to take input from brain signals (EEG).

Fig.11. Glove Using Flex Sensor

Future research can enable the use of shape memory alloy (SMA) to replace the servo motors that will enhance the performance of the robotic hand and provide a silent grasping motion.

3. CONCLUSION

The design, fabrication and testing of an anthropomorphic robotic hand system integrating innovative interactions of electrical, mechanical, software and control solutions has been successfully accomplished. The integration of sensory and actuation devices was complex and troublesome development phase where all the connections and operations needed to be programmed precisely to minimize garbage values and reduce fluctuations. In addition to this, adding wireless capability to the system was a daunting task which nevertheless was achieved. The future prospects of this paper are immense with regards to the industrial applications and there is margin for innovation to further enhance the functionality of the A.H.G.S.

4. REFERENCES

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