Two Finger Gesture Imitating Animatronic Hand

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Abstract. This paper poses the discussion regarding animatronics that has been aided with modern trends in technological innovations. The ease of availability and procurement of present day items incorporate economical factors into research. To accomplish the aforementioned, a simple two fingered hand model has been developed that can be remotely controlled using a glove. The glove can be manipulated via a hand. It has been electronically modulated using Arduino Uno and servo motors. The discussion has been furthered to the amalgamation of future developments that can pave the way for commercialization of such devices. Hardships and challenges faced during building of the model and experimentation of the finalized model are detailed.

1. Introduction
The word “Animatronics” entomologically merges “Animate” and “Electronics”. Thus, as suggested it is the technology behind animating objects to imitate humanoid gestures and actions. It can be commonly observed in motion pictures beginning with Disney’s Mary Poppins. The concept dates back to 3rd Century BC where it finds mention in the script of Liezi (Chinese Scripture). Its first modern day usage was for novelty clocks that were adorned with automated birds in 12th century and with the rapid advances in robotics, anatomy and mechantronics has expanded its scope to a multitude of areas such as prosthetics, industrial robotics and anthropomorphism. Robotics is advancing from remote location usage to being integrated in technology that we interact with on a daily basis. A way to humanize these robot-human interactions is to make robots imitate human gestures. Animatronics has been a step in this direction. There are many prevailing industry situations where human contact can prove to be dangerous or even lethal such as handling of hazardous chemicals, contacting Super-hot or Super-cold fluids or even entering narrow enclosures. A robotic industrial hand can help to improvise this situation to perform human-like actions of inspection or handling of injurious materials. Mishra et. al. [1] discuss the exploitation of Bluetooth feature in smartphones to transmit gesture information for remote control of industrial robots. They cancel the processing time lag enhancing the advantages of distant controllers. For specially-abled persons, animatronics is the basic step towards the development of prosthetic limbs. A hand that is capable of delivering humanoid movement to an artificial limb using electrical sensor can be a boon to many. This is achieved by anthropomorphizing the advanced animatronic limbs and extending the expanse of sensors. Kumar and Kumari [2] present a review of
the control features of animatronics powered prosthetic hands. They elaborate upon the current complications in prosthesis and develop on the various technologies in utilization at present. The utilization of animatronics is expansive, as explained by Oo et. al [3] in their innovative approach to reinforce the aid provided to the deaf and dumb by incorporating a gesture governed robotic arm. A major consideration during such a development is also keeping the financial aspect in check as technology has to be affordable to even small scale industrial houses and economically weaker section of physically challenged people.

There has been present day sophisticated research on such a concept. Pradeep and Paul [4] illustrate the gesture based control of a robotic arm. They achieve this by using accelerometer to sense the gestures that are then processed and transmitted to the robotic arm using an RF transceiver module. They generate the user friendly and accurate model to aid human intervention in industrial processes. Crisman et. al [5] present their innovative technique regarding the design of a robot hand. For this they incorporate the functioning of the tendon structure of a human hand into their mechanical model. They optimize the work freedom available to fingers by developing their model with pulleys and algorithm for control using switches. Ramaswamy and Deborah [6] lay out a comprehensive research on the contemporary robotic hands that are commercially accessible. They include in the descriptive survey and the advancements along with the multitude of problems encountered. Jog et. al [7] worked on a wireless animatronic hand that coalesces the modern technology of wireless communication using a XBEE module and the programming ease of Arduino Uno as a microcontroller. The result was a robotic hand with possible distant interaction but with scope of future effort to make movements more precise. Similarly, Gupta et. al [8] talk of the scope of extending the wireless robotic hand technology to a prototype arm. They dwell on the use of XBEE as an interface for wireless communication and involve the sophisticated signal processing of Arduino Uno. Utture et. Al [9] dwell on the concept of animatronics and its timeline. They discuss the amalgamation of robotics and animatronics as well as the prescribed methods for using these rapidly developing innovations. Bilgin et. at [10] has written about the purposeful usage of flexible sensors on finger tips of controller gloves to increase the precision of the animatronic movement. They discuss the use of RF 435 MHz module for wireless functions and embedding of the system with a digital interface for the proper implementation of the same. Chowdhury [11] has worked up the basic model for an animatronically controlled hand. She employs Arduino Uno and servo motors for developing communication between the controller and receiver. She goes on to discuss the economic limitations due to usage of flex sensors, the unnecessary employment of excessive sensors and the loud servo motor sounds.

In this paper, a basic model of an animatronic hand is developed. The basic outline of the logic employed is depicted in figure 1. The controlling glove has been provided with flex sensors to transmit signals corresponding to motion in the fingers of the person who dors the glove. Syed et. al. [12] have explored in detail the mapping of a hand motion to subsequent robot model. The wireless communication basis has been concluded that enhances the employment of the mentioned robots. The signal communicated via the sensors is converted by an Arduino Uno and sent to the servo motors which control the sample tendon structure mounted on the robotic hand. This paper serves to discuss the socio-economic impact factor with the improvement in present day technology. The challenges faced with the use of flex sensors have been addressed and the ease of making the basic animatronic research available worldwide has been developed.
2. Methodology, Design and Experimental Setup

2.1. Design Specifications
The gesture imitating hand was divided into two sections, one being the controller part or the part consisting of the glove to be worn by the controller and the Arduino Uno microcontroller to convert the flex sensor signals to signals compatible with servo motor movement, the other part being the mimicking part or the model hand that mimics the movements as gestured by the controller and the servo motors that cause the motion in the model fingers. The design of entire system began from the controller part. An everyday usage glove was procured. The glove should be a tight enough fit on the hand of the controller so that the flex sensors can precisely detect any movement of the fingers. For the basic model, two fingers ie. the thumb and the ringer finger were taken into consideration. The flex sensors were attached to the abovementioned fingers. These flex sensors were electrically connected to a bread board and then an Arduino Uno. The microcontroller was fed information from a laptop and was connected to two servo motors through another bread board. The servos were fed two strings which were attached to the model hand. In this case, the two-fingered hand was modeled using cardboard. The fingers were capable of bending in three stages like an anthropoid and the strings were fastened across the finger length.

2.1.1. Flex Sensors. Flex sensors are devices that convert the angle at which they are bent to a change in resistance, with the increase in the bending angle, the resistance of the device increases. It is usually connected across a voltage divider circuit that converts this increase in resistance to a proportionally linear increase in voltage. This voltage signal can be easily manipulated for further usage. For this project, two 2.2 inch flex sensors were procured. The two terminals apart from being present in a voltage divider circuit were connected to the ground terminal and the terminal of a power source present on the Arduino board.

2.1.2. Resistors. Two resistors were employed to successfully convert the resistance signal from the flex sensor to a voltage signal for downstream ease of manipulation. For this, two resistors were acquired with the Red Red Brown Gold colour code that translates to 220 Ohm.

2.1.3. Arduino Uno. This is a microcontroller board that employs 6 input analog pins and 14 digital I/O pins and is easily programmable using the Arduino IDE which is an application that is cross platform and can be worked upon with the basic knowledge of C or C++ languages with just a few changes in the structuring. The board is USB base. It was used to convert the analog voltage signal input to digital signal output compatible with the servo motors.

2.1.4. Bread Boards. They are convenient and cost effective devices to produce circuits using jumper wires without having to solder. This effectively reduces the connection time and also professes safety. The financial aspect is another advantage as they are inexpensive and widely available. They come in
a variety of sizes. For this model, a full (6.5cm X 17cm) and half size (5.5cm X 8.5cm) breadboard were utilized.

2.1.5. *Servo Motors.* Since the model employs two fingers to configure a basic circuit. Two SG90 servo motors were used. A servo motor has 3 terminal wires which are brown, red and yellow in colour. The brown wire is connected to ground terminal and yellow to the respective output terminals of the digital section of the Arduino Board. The red wire in connected to an external battery source, which in this case was taken as a 9V battery. Two strings that acted as tendons were mounted on the Servos. The servos convert the signal to the desired angle of the blade. This exerts a pull on the strings which subsequently move the fingers of the model hand.

2.2. *Methodology*

There are two major sectors that required focus, one being the electrical circuit and the other being the program fed into the Arduino.

2.2.1. *Electric Circuit.* While developing the circuit, the main aim was to manipulate the signals received from the flex sensors into angles of movement of the Servo motors that would invariable pull on the tendonic strings to imitate the movement in the model hand. Starting from the controller section, the basis of the electrical circuit was to join a terminal of both the flex sensors to the ground terminal of the Arduino via the negative terminal of the breadboard. This has been depicted by the black coloured circuit lines emerging from the Flex Sensors in figure 2. The other terminal of the flex sensors were supposed to be connected to a fixed voltage source via the positive strip of the breadboard as shown as the red coloured lines originating from the flex sensors in figure 2. On the same connection, resistance drop had to be added to develop a voltage divider circuit which was then connected to the 2 analog input terminals of the Arduino board. This can be evidently followed along the brown coloured circuit lines concluding in the T1 and T2 input terminals of Arduino Board in figure 2. Moving to the controlled part of the prototype, the digital I/O terminals of the Arduino board were then connected to one terminal of the Servo. These brown connection lines (figure 2) serve the purpose of transmitting the manipulated signals to the Servo motors to move the hand extension. The other two terminals were connected to negative terminal of the battery as well as the ground terminal of the Arduino board and positive terminal of the battery. These can be respectively traced as the black and red coloured circuit lines traversing towards the battery respectively in figure 2. The servos were connected using a tendon functionality thread. A constant power source was required to locomote the modeled two finger hand. This was provided through the Arduino Uno being connected to a power source, abetting the red power lines in figure 2.

![Figure 2. Electronic circuit used for development of design](image)
2.2.2. Arduino Program. Figure 3 shows the code which was fed into the Arduino IDE and uploaded into the microcontroller. The code helped change the voltage analog signal received into a change in angle of the attachment rod mounted onto the servo. As the angle of the rod changed it exerted a pull onto the thread which further caused bending or flexing of the fingers of the model arm. Badamadsi [13] elaborates the functionality principles of Arduino Uno as a microcontroller by expanding on not only the hardware but the software as well. The method of compiling codes for further project development have been thoroughly examined as well.

```
#include <Servo.h>
Servo servo_motor1;
Servo servo_motor2;
int flex1=0;
int flex2=1;
void setup()
{
  servo_motor1.attach(9);
  servo_motor2.attach(10);
}
void loop()
{
  int flexpos1, flexpos2, servopos1, servopos2;
  flexpos1 = analogRead(flex1);
  Serial.println(flexpos1);
  servopos1 = map(flexpos1, 1020, 1023, 0, 180);
  servopos1 = constrain(servopos1, 0, 180);
  flexpos1 = analogRead(flex1);
  servopos1 = map(flexpos1, 1020, 1023, 0, 180);
  servopos1 = constrain(servopos1, 0, 180);
  flexpos2 = analogRead(flex2);
  Serial.println(flexpos2);
  servopos2=map(flexpos2, 1020, 1023, 0, 180);
  servopos2 = constrain(servopos2, 0, 180);
  servo_motor1.write(servopos1);
  servo_motor2.write(servopos2);
}
```

Figure 3. The Arduino code fed to Arduino IDE

3. Experiments and Results
The controller having access to the glove flexed his thumb and ring finger, first one at a time and then together. The model hand was seen performing the same activities. On checking the angle of the finger flex in case of the controller and the model hand, the difference between the angles was more than 15%. The error in precision of movement could be attributed to the fingers made out of proportion. If the length of the fingers of the animatronic hand are made proportional to real life fingers and the length of each section of the finger too made more anthropomorphic, this could reduce the error down to the scientifically acceptable level. These levels are set by each industry or phase of utility that demand the employment of such technology. A possible solution to such an issue can be the amalgamation of cost effectiveness and anthropomorphism. Bae et. al. [14] embellish such a concept to ensue upon a four fingered hand equipped with actuation. They dwell on the viability of controlling objects and the versatility of the applied science. At present, the resistors had to be replaced with ones having ohmic capacity of 22k Ohm. The reason for replacement being that the low level resistance caused early drainage of the 9V battery. If a long lasting source is available at the same level then 220
ohm resistors can be used. But, for optimized results replacement is advised. Chowdhary [11] expatiated over the probable use of Neoprene bend sensors for cost effective applications. With rapid globalization accompanied with torrid advances in technology, flex sensors are now easily obtainable at much lower costs. They can also be developed at home for more cost saving. Their easily availability denoted ease of procurement and hence time saving. Flex sensors are more sensitive than bend sensors as the later work on sensing pressure. As we are aiming towards a more precise model for industrial applications and enhancing gesture sensitivity, flex sensors should be the way to go. They no longer pose a cost barrier. Using a single flex sensor for more than one finger may not be the proper path because each finger has its own characteristic bend and flex. This bend has to be mimed accurately for furthering the project applications. The Servos were mounted on acoustic foam. This foam is capable of absorbing noise created by the Servos. This effectively solves the issue of lowering noise levels on the industrial floor when the animatronic hand advances to such employment. The project was developed at a low cost and hence suggested that with newer technology, the impact of such a device can be re-evaluated for the better.

4. Discussion
Technology is the science that can be made practically available to its beneficiaries. The gesture imitating basic animatronic hand was developed to check its socio economic standing with the advancements in present day technology. Be it the ease of component availability or the cost of their procurement, the hand was developed cost-effectively. This feature can be exploited in later stages where the hand can be anthropomorphized and made more precise. The time to develop such a project is also optimized with the worldwide obtain-ability of instruments. Any noise in the system is also efficiently reduced by deploying acoustic sponges which are again not a very substantial investment. The breadboards are definitely a superior substitution to soldering in terms of safety and material cost. These implications of the technical project talk bounds about its future evolution into more sophisticated models. The problem of precision in movement persist which remain to be addressed. In conclusion, the desired model and its predicted financial importance were achieved. The subsequent research can deal with the rectification of precision errors bearing in mind the reduction of possible inflation in costs that comes when using futuristc technology. The animatronic hand holds the potential for betterment of human-robot interaction.

5. Conclusion
The paper has developed a basic model for the gesture enabling remote control in an animatronic two-fingered hand. The problems faced during the concentrated effort on socio-economic steer as furnished by modern technology were elaborated upon. Certain possible ameliorations were suggested bearing in mind the basic aim of the research. Furtherance of the model may include the introduction of mechanisms for flat object picking and dynamics of humanoid object transfer.

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