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Modeling and Simulating Human Arm Robot

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***Abstract*—*Modeling and imitating human arm behavior is indispensable when robots interact with human operators. The current study focuses on the design and programming of a robotic arm within five independent degrees to accomplish missions accurately. These arm movements can be performed using a controller that drives servo motors and has the ability to adjust the position. The main objective of this paper is to design a robotic arm. The model will be accomplished by constructing the components together to simulate human arm motions in a way that can be controlled in different positions. The results will include the calibration and measuring output value as well as the flex sensor angle against the angle value of the servomotor. The achievement is when the movement of the robotic hand is flexible and smooth with the motion of the human arm to be used in different places to keep the arm of people safe.*

Keywords*— *Robotic, Wrist Motion.

I. INTRODUCTION

A robot is capable of carrying out tasks robotically with the help of supervision. Practically, a robot is an electro-mechanical machine that is guided by utilizing computer and electronic programming. Therefore, it can be classified as autonomous, semiautonomous, and remotely controlled. Recently, Robots have been widely used for a variety of tasks such as service stations, cleaning drains, and tasks that are considered dangerous to be performed by humans. In addition, A robotic arm is a robotic manipulator, usually programmable, with similar functions to a human arm. However, the problem of how to manipulate industrial robots that interact with human operators has attracted a lot of robotic researchers [1].

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II. ROBOTIC ARM

A robotic arm is a kind of mechanical arm which is programmable with similar operation to a human arm. The arm could be a whole mechanism or a system part of a robot more complicated. The links of a manipulator are connected by joints allowing rotational motion or translational displacement. The links of the manipulator can be considered to be chain motions [2]. The development of robotics has been slow since they were discovered in the early 1950s and had a limited range of useful applications related to space exploration. The use of robots to assist in industrialization was realized when robotic arms began to be integrated into automobiles and other manufacturing assembly lines. Similar working in a manner to the human arm, robot arms can still have a much wider range of motion since their design can be up to the creators[3].

The robotic hand has many different types some are related to the human hand and others are according to experiments. There are many researchers who designed robotic hands with different tasks and different structures. To determine the method to be used in the control of the robotic hand movement, XBee wireless communication protocols were used to communicate between transmitter and receiver [4].

Haruhisa Kawasaki and Tetsuya Mouri presented a humanoid robot hand and its applied research in 2018. The hand control system depends on distributed tactile sensors to control Gifu Hand III. sEMG and Voice control are used to control the hand [5].

A survey presented by Giovanni Saggio, Francesco Riillo, Laura Sbernini, and Lucia Rita Quitadamo in 2016 about how the resistive flex sensors can be used to measure bending or flexing with relatively little effort and a relatively low budget [6]. A Hand-Eye Calibration is presented by Radu Horaud and Fadi Dornaika in 1995. An article talks about the way to determine the relationship between the sensors of the human hand and the movement of the robot hand [7].

III. METHOD

With regard to Hardware of this robotic-arm design, it has been used the flex sensors and Accelerometer x,y, and z sensors for movement for all arms. These sensors are put on an arm glove, which will make the sensors easy to wear. The other part of the mechanical hand consists of 3 fingers, and an elbow, which are controlled with the help of six servo motors. Altogether it will be one arm consisting of 3 flex-sensors one on each finger, and Accelerometer x,y, and z sensors on the wrist.

In software, A movement like the bending of fingers, and wrist. is analyzed using Arduino UNO and the resultant data will be sent to Serial Port Module for controlling servo motors. The complexity of the project is reduced by properly categorizing the whole project into sub-design. The readings of each movement were measured in the form of voltage while the movement of each finger, and wrist will be given concerning the angle.

IV. SYSTEM COMPONENTS

A. Arduino UNO

The Arduino UNO R3 is a great board used for coding and electronics. The microcontroller is set with the well-known ATmega328P and the ATMega 16U2 Processor.

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Fig. 1. Arduino UNO

B. *Servo Motors*

Servo motors are electrical devices that can rotate an object with a high precision. These motors are used to rotate an object at some specific angles or distance. It is just made up of a simple motor that runs through a servo mechanism. It can be getting a very high torque servo motor in a small and lightweight package. Due to these features, it is being used in many applications like robotic.

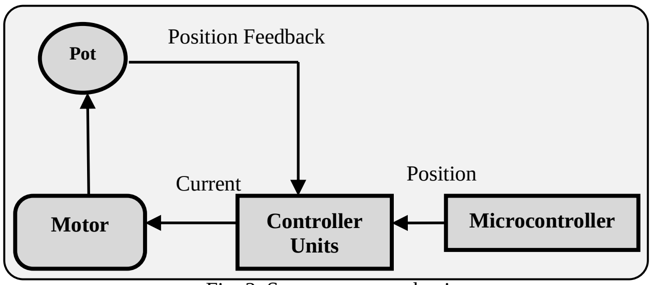

Fig. 2. Servo motor mechanism

The servo motor mechanism is called a closed-loop control system that uses a positive feedback system to control the shaft position. The feedback signal will be generated from the difference between the output signal and the reference input signal.

The reference input signal is compared to the output signal and the third signal is produced by a feedback system. The third signal acts as the input signal to the control device. This signal is present as long as the feedback signal is generated or there is a difference between a reference input signal and an output signal, therefore, the main task of servomechanism is to maintain the system output at the desired value. The potentiometer is connected to the shaft output of the servomotor to calculate the angle and stop the DC motor at the required angle.

C. *Flex Sensors*

A sensor that gauges the degree of bending or deflection is called a bend or flex sensor. Typically, the sensor is adhered to the surface, and the surface can be bent to change the resistance of the sensor element. Since the resistance is directly proportional to the amount of bend it is used as a goniometer, and often called flexible potentiometer [8].

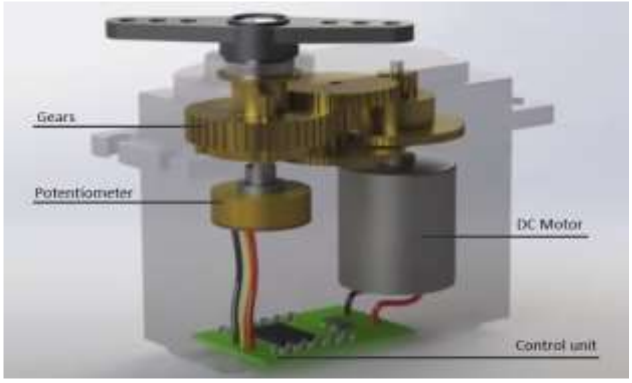

Fig. 2. Servo motor contracture

Fig. 4. Flex sensor

Flex sensors are used in wide areas of research from computer interfaces, rehabilitation, security systems, and even music interfaces [6]. In each application, the sensor identifies the flexure in terms of varying resistance that can be recorded digitally, and the data is then used differently depending on the application.

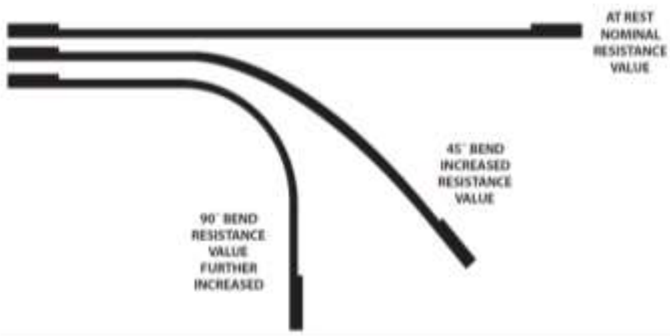

Fig. 5. The principle work of flex sensor

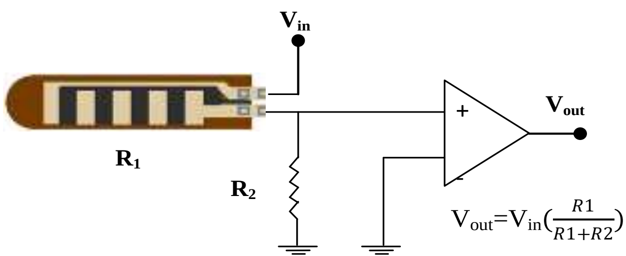

Fig. 6. Basic flex sensor circuit

Flex sensors describe changes in resistance depending on the amount of bend on the sensor. It converts the change in bend to resistance. It is usually in the form of a thin strip from

1"-5" long that varies in resistance from approximately 10 to 50 KΩ. Therefore, the Flex sensor can work as a variable analog voltage divider. Carbon-resistive components enclosed in a thin, flexible substrate make up the flex sensor. When the substrate is bent the sensor produces a resistance output relative to the bend radius.

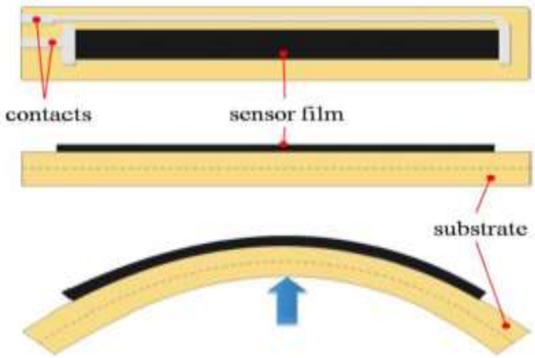

Fig. 7. Flex sensor structure

D. *Accelerometer*

It is important to note that acceleration creates a force that is captured by the force-detection mechanism of the accelerometer. So, the accelerometer measures force, not acceleration; it measures acceleration indirectly through a force applied to one of the accelerometer's axes. Another electromechanical device that is manufactured using microfabrication technique is an accelerometer, which similarly has holes, cavities, springs, and channels. Accelerometers measure acceleration forces by detecting the displacement of the mass with respect to fixed electrodes. They are made using a multilayer wafer method.

Capacitance sensing, which links acceleration to a change in a moving mass's capacitance, is a popular sensing technique used in accelerometers. The great accuracy, stability, low power dissipation, and ease of construction of this sensing technology are well known. It is not sensitive to temperature changes or noise. A capacitive accelerometer's physical shape (spring) and the air trapped inside the IC, which functions as a damper, limit its bandwidth to a few hundred Hertz.

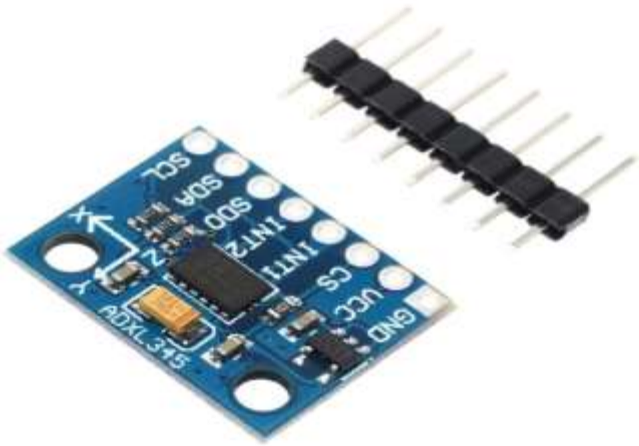

Fig. 8. Accelerometer sensor

V. SYSTEM DESIGN

To design a robotic arm, many types of shapes and materials depend on the practical requirements, so there are different types of metals, wood, and steel. In this project, the design of the robotic arm has been taken from the InMoov company site with little adjusting in the main design. The arm will be printed by a 3D. The next stage will be inserting the 3D objects in a program that gives an order to a 3D printer to print the model designed using PLA+ material.

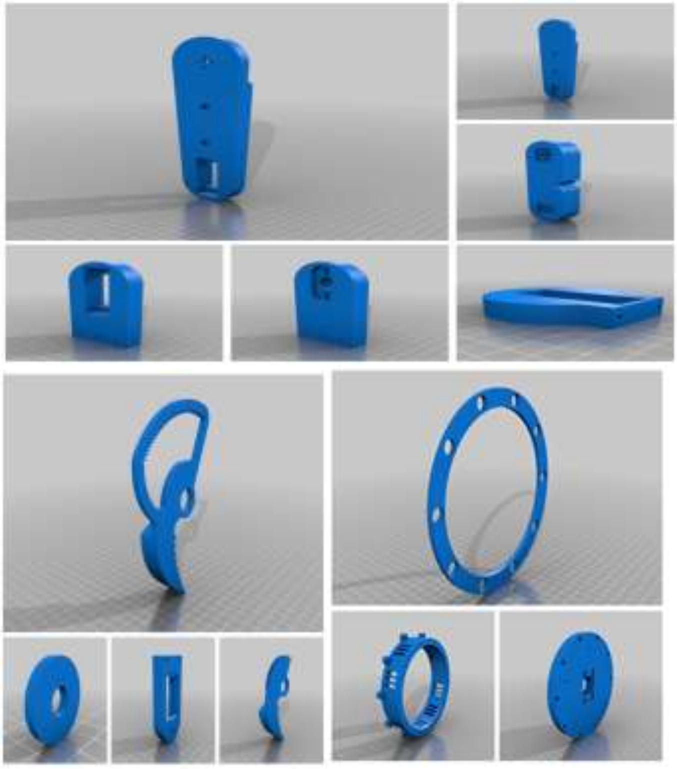

Fig. 9. Design of arm components

Fig. 10. All components together

Fig. 11. Robotic arm

Flex sensors are generally available in two sizes: one is 2.2inch (5.588cm) long and another is 4.5inch (11.43cm) long as shown in the figure. To connect the flex sensor with Arduino NANO, a 10kΩ pull-up resistor is put in series with the flex sensor to create a voltage divider circuit, then the point between the pull-up resistor and the FSR is connected to the A0 ADC input of an Arduino.

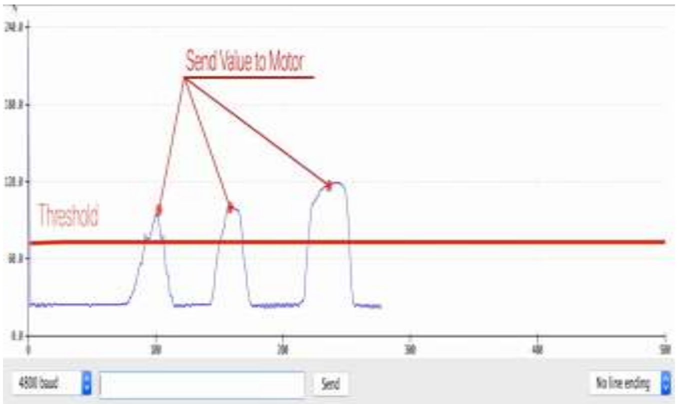

Fig. 12. Flex sensor output value

To test a servo motor, it will be used a sketch to rotate the servo from 0 to 180 degrees and from 180 to 0 degrees. The servo motor has a female connector with three pins that allows it to do this. The ground is frequently the darkest, if not the blackest. Link this to the ground. Attach the power wire to the Arduino's 5V port, which by all standards should be red. A digital pin on the Arduino should be connected to the last line on the servo connector.

VI. RESULTS AND DISCUSSION

A. Calibration Input Value

When the flex sensor bends from zero angles to the final angle there is a range that must be taken in mind to acquire an accurate angle of bending. By using the function Serial print () in the main sketch of the transmitter, it makes it easier to monitor the values that the Arduino reads by the pins A0-A2. These values come from bending the flex sensor. When bending a finger, the value of its pin changes, and the maximum and minimum values of the pin are the range that comes from each finger to each pin. so the ranges of every flex sensor are measured as shown in the Table I.

TABLE I. flex sensor value

Angle value	Thumb	Forefinger	Little finger
Finger opened	778	680	505
Finger closed	890	850	852
Finger closed separately	810	735	785

To get all freedom angles, the minimum and maximum range will be the choice according to previous case studies. Moving fingers result from a change in voltage and the Arduino reads this value of change, then, converts it to angles and sends the data to the receiver by Arduino After choosing ranges from the tables, it will be used to set the angle for each servo that moves the robotic hand fingers. The function of the map () changes the range of the reading value of flex to range from 0 to 180 degrees for the motors. The glove arm, a robotic arm, and sensors are connected to construct the whole project.

B. Calibration and measuring Output Value

In the receiver code, by using the function radio. available (), the program remains checking whether a message comes from the transmitter or not. When there is a message, the Arduino sends a signal to the servo motors to move to the desired angle. When observing the movement of the robotic fingers according to the angles, it will choose an angle range that gives the right finger position, like the ranges in Table II.

TABLE II. Flex sensor range

Angle value	Thumb	Forefinger	Little finger
Flex sensor range	778-890	680-850	505-852
Servo angle range	0-100	0-90	0-70

TABLE III. Flex angle with servo angle

Flex angle	0	15	30	45	60	75
Servo angle	0	10	25	42	60	80

VII. CONCLUSION

The model of the robotic arm is designed and printed using a 3D printer as well and the robotic arm components are assembled where the servo motors are used as the actuators and the flex sensors are installed on the standardized glove to get the movement of the human arm. Moreover, the microcontroller Arduino Uno is utilized to control the model by wired-to-move motors. The evaluation of the motion range of the robotic glove and its ability to provide different motions is achieved by observing the response of the robotic arm to the movement of the human. Finally, the main objectives of the project are achieved when the movement of the robotic hand is flexible and smooth with the motion of the human arm. Therefore, this model can be used in dirty and dangerous places to keep the arm of people safe.

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