HAND GESTURE CONTROLLED BIONIC HAND

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Abstract—Bionic hand is an artificial hand that can be replaced by a missing Human hand. In medical science, Bionic hand is an artificial hand that replaces a missing human hand, which may be lost through trauma, disease, or congenital conditions. A bionic hand can be useful as a replacement to human hand. It just needs to be controlled by a human thus allowing a human to believe that he is actually there doing that task. The Bionic hand can perform various operations and can be replaced in the form of prosthetic limbs with the help of a microcontroller programming. The main goals is to make an efficient manipulator (minimalistic approach).The aim is to design a bionic hand with 5 fingers and that gives ability to grasp objects of various shapes. The bionic hand will always copy human hand Movements. This plays a vital role in military, industrial, medical and many other fields

Keywords— Bionic, Gesture, Prosthetic, Flex sensor artificial hand.

I. INTRODUCTION

There are many patients who are disabled after going through accidents or sustained neurological damage. The high stroke incidence in combination with an aging population, which implies future increases in incidence, greatly strains national healthcare services and related costs. In the majority of these cases, patients experience either partial or total absence of hand motion ability, and this loss of functionality can greatly restrict activities of daily living and considerably reduce quality of life. High intensity and task specific upper limb treatment consisting of active, highly repetitive movements is one of the most effective approaches to arm and hand function restoration. Unfortunately, Standard Stroke rehabilitation is labor intensive and requires one-to-one manual interactions with therapists. Treatment protocols entail daily therapy for several weeks, which makes the provision of highly intensive treatment for all patients difficult Therefore, a mechanic is required to support this work automatically.

An intelligent Bionic hand is defined as a hand that mimics the natural movements of the human hand. In order to appropriately mimic the motion of the human hand, its natural motions must be studied carefully. The project aims to develop Bionic Hand, whose movements can be controlled by moving the controlling person's hand. The Bionic Hand copies the movements of the controller's hand. The movements of the user's fingers are sensed by using a set of sensors attached to the joints of his finger. As the position of the finger changes, the corresponding parameters also changes.

A. *Problem Statement*

In present scenario there are many people who have disability in hand, and those people are unable to perform various tasks, due to complete missing of the other hand. There are many industries where human hand is a must to complete the required task, but it may harm human skin or bones. So instead of using actual human hand, we can replace it by wireless Bionic hand. So this bionic hand can be used to complete the same task so that the risk will be avoided and required task can be achieved. The objectives of the project are to ensure that the research will fulfill the solution of the problem. All the objectives are shown below:

a) To design and develop a Bionic hand using wireless module Technology
b) To design and develop the prototype of the Bionic hand which can be a part of human robot and can be used in many applications.

B. *Bionic Hand*

In the field of robotics and industrial equipment's, use of proper method of handling the chemicals, equipment's etc. is very important from safety point of view. Traditional method of handling the chemicals as well as equipment's was done normally with the help of bare hands. With the bare hand it is not possible to hold the equipment's and chemicals for a large amount of time and due to this there is a matter of safety as well as there is no proper precision. With the new innovations in the field of science i.e. Bionic hand, we can do all such tough tasks with higher amount of precision and higher amount of safety.

Bionic hand is developed which is controlled via control glove. The control glove has flex sensors, accelerometer which detects the movements of fingers, wrist, elbow and accordingly Bionic hand perform the required tasks. The Bionic hand is able to be controlled according to the controller's hand. It is capable of moving at the required degrees of freedom. It can also pick up things up to minimum desired weight. We can use it as shadow hand of ours which is of various use. With the help of sensors this hand can provide detailed telemetry, which can be exploited to generate innovative manipulation, control systems, or to provide detailed understanding of the external environment.

II. BLOCK DIAGRAM

The block diagram consists of two sections: The transmitter section and the receiver section.

A. Transmitter Section

The transmitter section consists of flex sensors, potentiometers, accelerometer, a microcontroller and an XBEE S2C transmitter and power supply as shown in Fig 2.1

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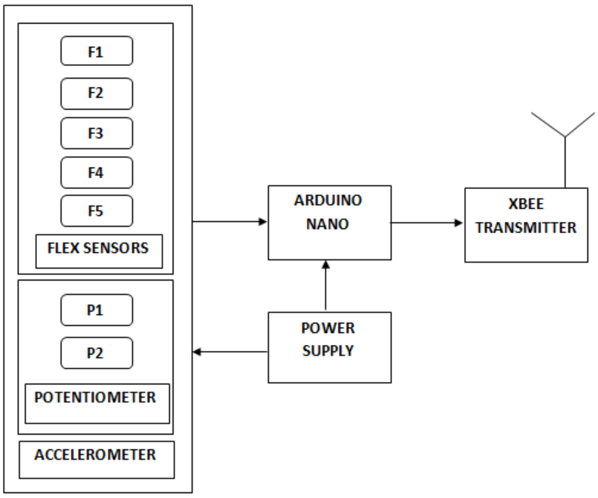


Fig - 2.1: Transmitter block diagram

The 5 Flex sensors are mounted on a control glove. Each flex sensor is attached to individual finger, These 5 flex sensors are to control the moment of 5 fingers of the Bionic hand. Two potentiometers are used to control the elbow moments of the bionic hand and these potentiometers are mounted onto the controlling hand along with flex sensors. The accelerometer is used to provide the wrist moment for the Bionic hand. All the data from the flex sensor, potentiometer, and accelerometer are passed to ATMEGA328 microcontroller where the analog to digital conversion of data takes place and processing and mapping of data is done by the microcontroller. The processed data are put into a block structure and transmitter wirelessly via XBee S2C transmitter.

The Analog data from the five Flex sensors and from the other sensors are converted to digital with 10 bit analog to digital convertor using the microcontroller and the obtained digital values (between 0 to 1023) are then mapped to the range of 0 to 180, which is suitable to drive servo motors. These values are transmitted to the other end using XBee module through air medium.

B. Receiver Section

The other part of the block diagram is receiver section. The receiver section consists of an XBee S2C receiver, a microcontroller, servo motors, Bionic hand and power supply as shown in Fig 2.2

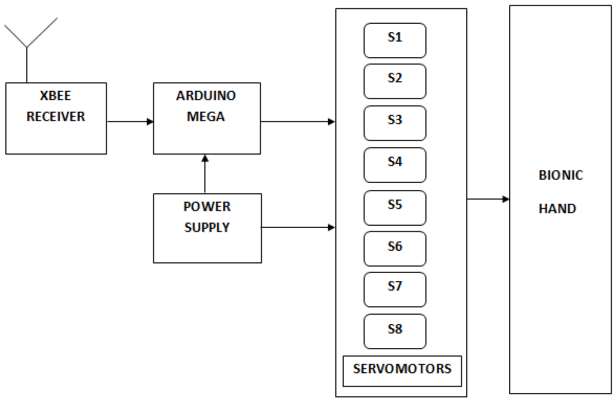


Fig - 2.2: Receiver block diagram

The 8 servo motors are used to drive the Bionic hand. Where the 5 servo motors (S1 to S5) are used to drive the 5 fingers of the Bionic hand and the servo motor S6 is used for the wrist moment of the Bionic hand and the servo motors S7 and S8 is used to provide the elbow moment to the Bionic hand. The microcontroller used here is ATMEGA2560 which performs the data processing and drives all the servos attached to it.

The data is received by XBee S2C receiver and is further transmitted to the Arduino mega which holds ATMEGA2560 microcontroller. The block of data received consists of servo drive values (between 0 to 180) and these values are pulse width modulated and passed to the particular servo assigned to each controlling sensor, further these servo's drive the bionic hand and performs the tasks. The power supply used is 5V, 2.1A DC supply.

C. Flex Sensor

Flex sensors are analog resistors. These resistors work as variable analog voltage divider. Inside the flex sensor are carbon resistive elements with thin flexible substrate. More carbon means less resistance. When the substrate is bent the sensor produces resistance output relative to the bend radius. The flex sensor achieves great form-factor on a thin flexible substrate. When the substrate is bent, the sensor produces a resistance output correlated to the bend radius as shown in fig 3.1. Smaller the radius, higher will be the resistance value.

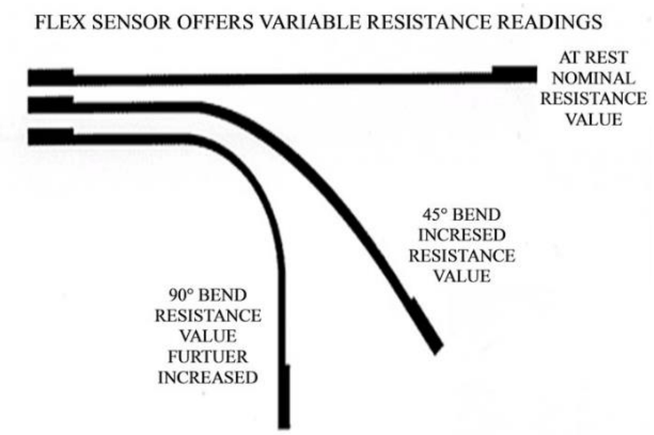


Fig - 3.1: Flex Sensor

The impedance buffer in the circuit is a single sided operational amplifier used with these sensors as shown in Fig 3.2. Since low bias current of the op amp reduces error due to source impedance of the flex sensor as voltage divider. The variation in deflection or bending of flex sensor results in variation of resistance itself. The signal conditioning circuit is used to read these resistance changes and it is given to ADC pin of microcontroller.

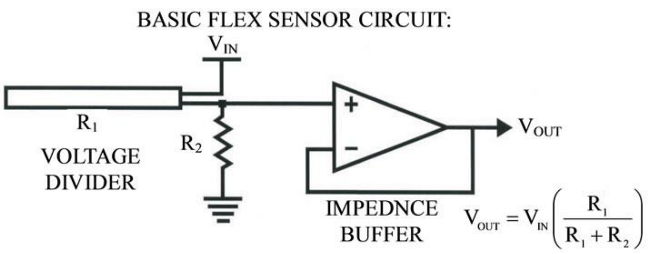


Fig - 3.2 : Flex sensor circuit

D. Accelerometer

An accelerometer is an electromechanical device that will measure acceleration forces. These forces may be static, like the constant force of gravity pulling at your feet, or they could be dynamic caused by moving or vibrating the accelerometer. Below Fig 4.1 shows accelerometer ADXL335.

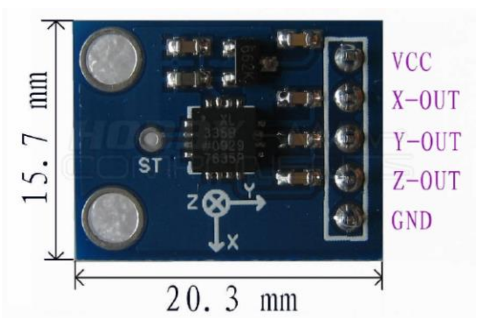


Fig – 4.1: Accelerometer

As shown in fig 4.2 the accelerometers with an analog interface show accelerations through varying voltage levels. These values generally fluctuate between ground and the supply voltage level. An ADC on a microcontroller can then be used to read this value. ADXL335 is 3 axis accelerometer with on board voltage regulator IC and signal conditioned Analog voltage output. The module is made up of ADXL335 from Analog Devices. The product measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration.

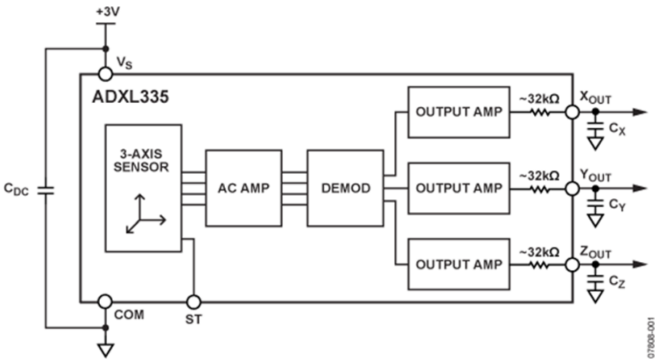


Fig – 4.2 : Internal Structure of Accelerometer

The sensor is a polysilicon surface micro machined structure built on top of a silicon wafer. Polysilicon springs suspend the structure over the surface of the wafer and provide a resistance against acceleration forces. Deflection of the structure is measured using a differential capacitor that consists of independent fixed plates and plates attached to the moving mass. The fixed plates are driven by 180° out-of-phase square waves. Acceleration deflects the moving mass and unbalances the differential capacitor resulting in a sensor output whose amplitude is proportional to acceleration. Phase-sensitive demodulation techniques are then used to determine the magnitude and direction of the acceleration.

The demodulator output is amplified and brought off-chip through a 32 kΩ resistor. The user then sets the signal bandwidth of the device by adding a capacitor. This filtering improves measurement resolution and helps prevent aliasing.

III. SOFTWARE

For programming Microcontrollers Arduino IDE is used. The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software. This software can be used with any Arduino board.

To configure and program XBee S2C Radio's XCTU Software is used. XCTU is a free multi-platform application that enables developers to manage Digi radio frequency (RF) modules through a simple-to-use graphical interface. The application includes embedded tools that make it easy to set up, configure, and test Digital RF modules.

A. *Tx End Flow Chart*

1. First initialize i.e includes easy transfer library which puts the data into an array and includes a checksum for the receiving side for data verification.
2. Assign the object for easy transfer library, and a data structure is created and named. As shown in fig 5.1
3. Capture the minimum and maximum valued out from the flex sensors, once they are powered up and assign to the variables.

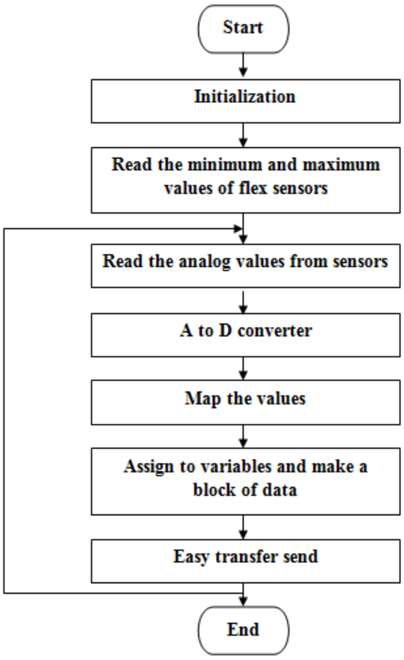
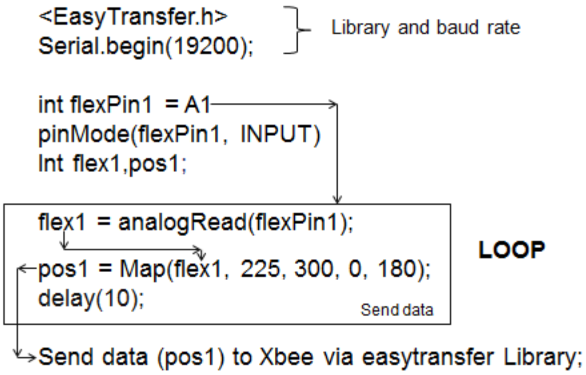


Fig - 5.1: Tx End Flow Chart

4. Read the analog values coming out from each sensor and convert the corresponding values to digital form and store the digital values to a variable.
5. The digital values are mapped to each sensors minimum limit and maximum limit.
6. The mapped values are assigned to a variable and stored. An array is made and all the values are stored in an array.
7. The block of data, the array is now send to another Xbee(Receiver) via easy transfer sent algorithm

B. *Algorithm*

The Analog pin A1 is defined as the input pin to which the voltage values are fed from various sensors. These voltage values are read using analogRead() instruction and the value so read is converted into digital and is mapped to the specified range (min and max values of sensors). Finally the mapped value is assigned to a variable and the data is transmitted with 10msec delay. The above logic can pe applied to all the other sensors connected.



C. *Rx End Flow Chart*

1. Initialize and include easy transfer library which receives the block of data and includes a checksum for data verification and also includes servo libraries.

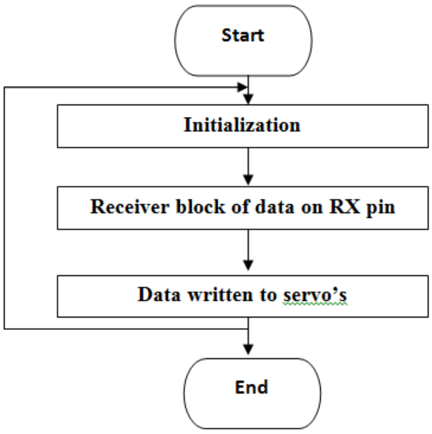


Fig – 5.2: Rx End Flow Chart

2. Assign servo to each object created and a structure: Receive_data_struce is formed and receives the data of the baud rate 19200. As shown in fig 5.2.
3. The whole array is received and using the checksum the received data is verified.
4. The data so received is written to the servo's attached to the PWM pins.

D. *Algorithm*

All the eight servo motors are attached and assigned to PWM pins of the Arduino mega and a structured block of data is received at the receiver end by using ET.receiveData() instruction. The values received (between 0 to 180) are assigned to the particular servo as defined. Accordingly the servo motors rotates and controls the bionic hand.

```
servo myservo;
int servoPin1 = 3;
pinMode(servoPin1, OUTPUT);
```

```
{
ET.receiveData();
myservo.write(pos1);
delay(10);
}
```

Receives pos1 values from tx

Loop

E. XCTU Radio Configurations

There are a few levels to X-Bee networks. First, there is the channel. This controls the frequency band that over that X-Bee communicates. Most X-Bee's operate on the 2.4GHz 802.15.4 band, and the channel further calibrates the operating frequency within specified band. We can usually leave the channel setting alone, or at least make sure every X-Bee you want to have on the same network operates on the same channel.

TABLE I. RADIO CONFIGURATION SETTINGS

Co-ordinator	**Router**
Pan ID – 1234	Pan ID – 1234
Destination Address - 13A2	Destination Address - 13A9
My Address – 13A9	My Address – 13A2
Channel C	Channel C
Baud Rate – 19200	Baud Rate – 19200
coordinator – 1(enable)	coordinator – 0(disable)

The next level of an X-Bee network is the personal area network ID (PAN ID) . The network ID is some hexadecimal value between 0 and 0xFFFF. X-Bees can only communicate with each other if they have the same network ID. There being 1234 possible ID's, there is a very small chance that your neighbor will be operating on the same network. Finally there are MY and destination addresses. Each X-Bee in a network should be assigned a 16-bit address (again between 0 and 0xFFFF), which is referred to as MY address, or the "source" address. Another setting, the destination address, determines which source address an X-Bee can send data to. For one X-Bee to be able to send data to another, it must have the same destination address as the other X-Bee's source. Overall system performance is check wirelessly by using two different power supplies for transmitter and receiver. System is working properly. Signal reception time is almost negligible.

IV. RESULTS

It was first tested by wired connection ie without using XBee transceivers. Firstly just two servos were attached to two fingers of the Bionic hand and controlled by two flex sensors as shown in below fig 6.1

Fig - 6.1: Finger testing

After the successful actuation of these two fingers, the rest of the fingers were tied up with servos, tested and controlled by the control glove using XBee S2C transceivers as shown in below fig 6.2

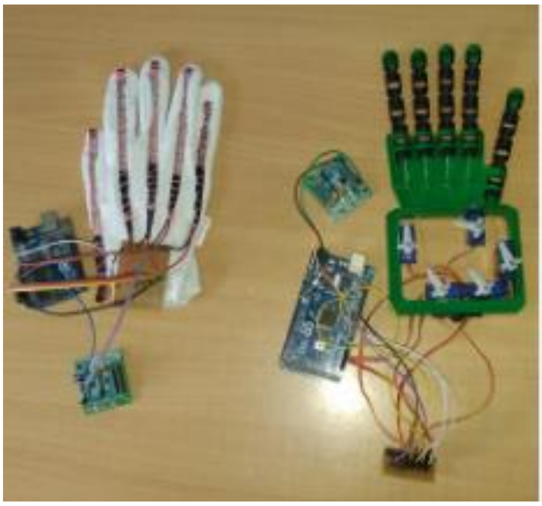


Fig - 6.2: Glove Setup

Further the 2 potentiometers for elbow control and accelerometer for the wrist control of the bionic hand were added and the arm was designed and laser printed. The whole setup is shown in below fig 6.3.

Various Sensors	**Sensor Voltages**		**analogRead() values from Arduino**	
	Min	***Max***	***Min***	***Max***
Flex s1	1.67V	2.24V	340	460
Flex s2	1.85V	2.20V	380	475
Flex s3	1.76V	2.35V	350	490
Flex s4	1.60V	2.23V	320	470
Flex s5	1.5V	2.10V	310	445
Pot 1	2.15V	3.20V	312	510
Pot 2	2.05V	3.10V	304	490
Accelero -meter	1.23V	1.70V	200	600

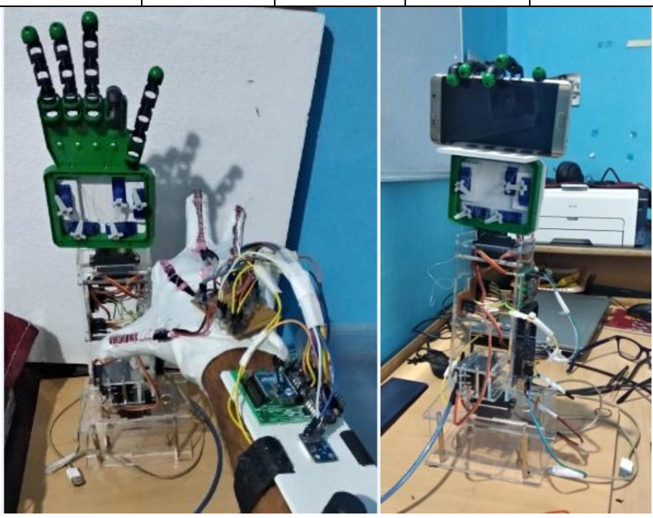


Fig – 6.3: Final Setup

TABLE II. RADIO CONFIGURATION SETTINGS

The 'analogRead' on an arduino is basically a voltage meter. At 5V (its max) it would read 1023, and at 0V it reads 0. So the bend can be measured using the change in the voltage values using analogRead(). A voltage divider circuit is generated using a 10kOhm resistor with the flex sensor. The following are the voltage values for the five flex sensors, two potentiometer and accelerometer.

V. Conclusion

The project presents a bionic hand, which is implemented by using flex sensors. It can be widely used where there are restrictions or a hazard to a human hand. This bionic hand can be controlled in real time, according to the hand gesture of the operator.

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