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Design of Robotic Arm based on Hand Gesture Control System using Wireless Sensor Networks

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Abstract - *In many industries wireless operations are necessary especially in dangerous or hazards areas. In some of the industries it is necessary to handle few jobs with very high temperature which is not possible by human hand in such cases wireless operations are more efficient. This paper focuses on design of hand gesture controlled robotic arm using microcontroller with the help of X-bee and wireless sensor networks. Simulations are being carried out and the hardware prototype was successfully implemented with the above requirements.*

Key Words: **Robotic manipulator, hand gesture controlled arm, flex sensor, X-bee, Accelerometer.**

1. INTRODUCTION

In today's life automation plays very important role. Robotic arm is called as robot manipulator which can perform various functions as human arm performs. Many industries use a robot for various functions where important part of any robot is Robotic arm or called as robot manipulator should be controlled precisely depending upon application. In industry or any application robot manipulator can be used for applications like welding, trimming; picking etc. advantage of such robotic arm is it can work in hazards area, which cannot be accessed by human. Many parameters of robot are designed according to requirement. There are different ways to control robotic arm like Voice Controlled, Keypad Control, Gesture Control, etc. Implemented system consists of transmitter & receiver. Transmitter is nothing but human hand with flex sensors & receiver is robot manipulator. Motion of transmitter is wirelessly transmitted to receiver through X-bee module. Robotic arm which is receiver is nothing but a mechanical system formed by different joints and end and effectors i.e. gripper movements of these fingers or gripper can be carried out using stepper motor or servo motor when user carry out motion of hand for any application at transmitter side same movement is copied by receiver as on transmitter there are flex sensors mounted on glove at transmitter which change its resistance depending on movement of user.

2. RELATED WORK

There has been many research works in the field of Hand Gesture based Human Computer Interaction following different algorithms to develop a fast and reliable procedure for gesture recognition. In Paper [1] – [6] by Francisco Arce, Jose Mario Garcia Valdez a three axis accelerometer has been used to read different types of Hand gestures. In Paper [7] – [11] by AnalaPandit, DhairyaDand, Sisil Mehta, ShashankSabesan, AnkitDaftery used a combination of accelerometer and gyroscope and the reading are taken in to for analyzing the gesture. Here accelerometer is dedicated for collecting translational dynamic and static change in positional vector of hand and infer it to the movement of mouse whereas gyroscope has been used for rotation of virtual object. There are many papers where gestures are being analyzed using colour gloves [12] – [15]. A data glove is a type of glove that contains fiber optics sensor or flex sensors embedded in it to recognize the finger movements.

Hand gesture recognition using image processing algorithms many times involve use of colour gloves. By tracking this colour glove different hand gestures can be interpreted as described by Luigi Lamberti1 and Francesco Camastra in their paper [16] – [18]. Here they have modelled a colour classifier performed by learning vector Quantization. In Paper [19] by J.S. Kim, C.S. Lee, K.J. Song, B. Min, Z. Bien, a pattern recognizing algorithm has been used to study the features of hand. There are many Papers where training of hands using a large database of near about 5000-10000 positive and negative images are considered. But this procedure is very tiring and time taking.

For Hand gesture recognition, some researchers have tried to perform the early segmentation process using skin colour histogram Zhou et al. Paper [20] – [22] used overlapping sub-windows which is useful to extract invariants for gesture recognition, and distinguish them with a local orientation histogram attribute description indicating the distance from the canonical orientation. This makes the process relatively robust to noise, however, much more time consuming indeed. Kuno and Shirai defined seven different stages of hand gesture recognition. It includes position of the figure-tip. This is not practically realistic when we have only pointing gestures, but also several gestures, like grasping.

However, the invariants they considered inspired us for our defined invariants.

3. BLOCK DIAGRAM

The block diagram was shown in Fig.1 below. It consists of two parts which are interconnected by the wireless sensor communication systems. The X-bee will be acting as the transmitter and the receiver device system. The first part consists of gloves which were occupied by Li-ion battery, microcontroller and flex sensors. The second part consists of motor, microcontroller and robotic fingers through which the mechanical action takes place.

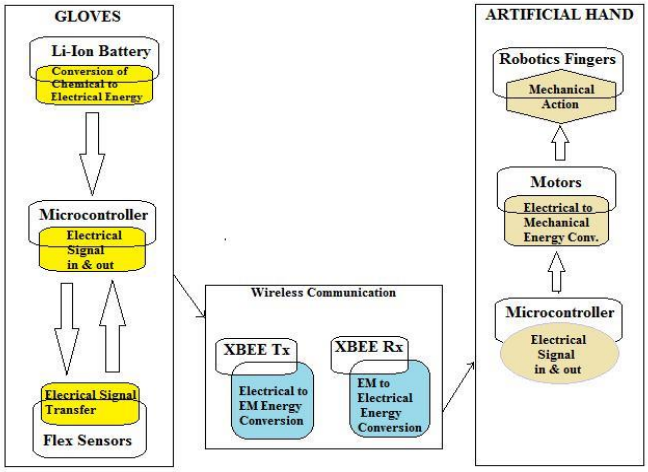

Fig -1: Functional Modeling analysis of the entire system

3.1 Transmitter

The below fig.2 is block diagram of transmitter consist of Microcontroller with two inputs from flex sensor & accelerometer.

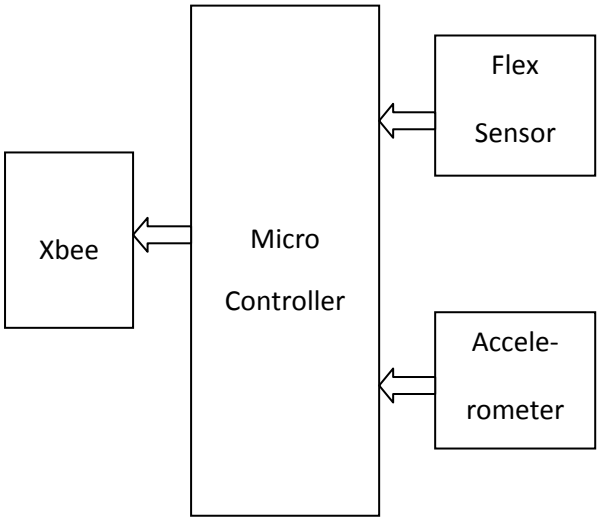

Fig -2: Block Diagram of Transmitter

As shown in fig, Flex sensors are analog resistors. It works as variable analog voltage divider. Internally it consists of carbon resistive element with thin substrate. As substrate is flexible when it is bent, sensor produces resistive output which is equivalent to bend radius. The flex sensor provides greater accuracy for small movements also. Smaller the radius higher will be the resistance value. These flex sensors are mounted on human palm as user moves palm for particular applications flex sensor also bends by same amount as they are flexible. The changes due to tilt of accelerometer are in forward, backward i.e. X-axis, left, right i.e. Y-axis and up, down i.e. Z-axis. Accelerometer converts deflection into proportionate voltage & Analog to Digital converter convert analog signal into proportionate digital value. So according to positive & negative deflections motor either rotates in clockwise or in anticlockwise direction.

3.2 Receiver

The below fig.3 is block diagram of receiver, in the transmitter side x-bee transmit the signal and this signal is received by the receiver X-bee and then fed to the microcontroller which drives motor through motor driver to control movement of robot manipulator. The sensor glove reads values from the flex sensors and correspondingly sends them wirelessly using X-bee protocol to the robotic hand. The operation is overseen and controlled with the help of Atmega16 development board.

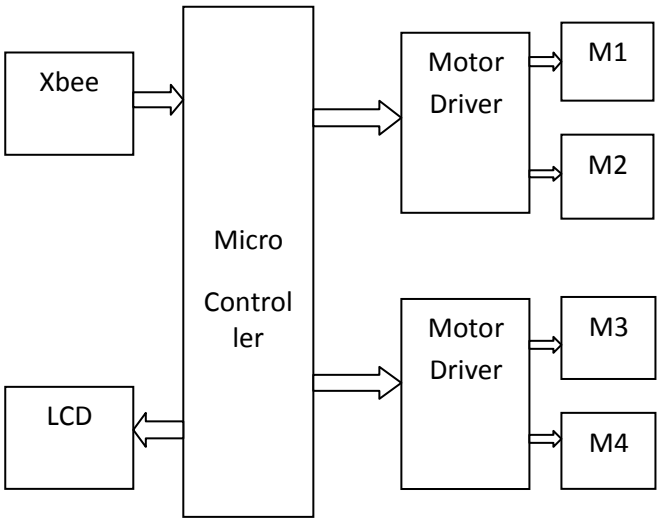

Fig -3: Block Diagram of Receiver

The sub module section with energy flow shown in Figure, gives a depiction of the operation within the sensor glove and with other peripheral components.

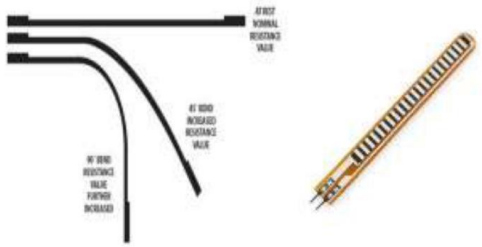

Fig -4: Flex Sensor

As shown in fig.4, flex sensors are mounted on each joint of all five fingers and bending of sensor due to hand movement of the operator changes the resistance of the sensor and this change in resistance is fed as input to the robotic unit.

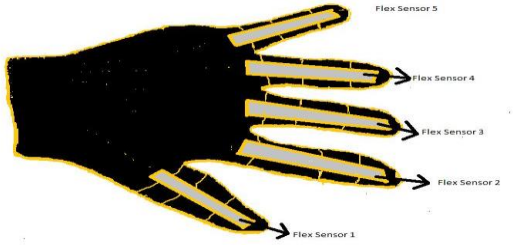

Fig -5: Robotic Hand Unit

The battery's chemical energy is converted into electrical energy and transmitted to the controller board. The board then coordinates the necessary actions by reading values from flex sensors or sending data wirelessly to robotic hand in Fig.5.

Fig -6: BO Motor

BO motor shown in fig.6 is used to move robot manipulator gripper in forward & backward direction.BO motor is brushless electric motor that divides rotation into equivalent number of steps. The position of motor can be controlled through these steps. It can hold one of these steps without any feedback sensor. If DC voltage is applied to the terminals of motor, it rotates contentiously. It accepts DC voltage as input & converts it into train of pulses i.e. square wave. Each pulse defines increment in shaft position, thus each pulse rotates shaft through a fixed angle.

4. SIMULATION DIAGRAM WITH RESULT

Below window in fig.7 shows simulation diagram with result in proteus. X-Bees are hugely popular wireless transceivers for a number of reasons. They are flexible – they send and receive data over a serial port, which means they're compatible with both computers and microcontrollers initially we connect the xbee module to the A-B cable and andusb port connected to computer and installing usb driver silicon labs cp210x. After installation we find silicon labs cp210x USB to UART bridge "COM28". Now we installed software XCTU and after opening XCTU we need to set communication parameters as shown in the figure9. Baud rate = 9600, Flow control = None, Data bits = 8, Parity = None, Stop Bits = 1. Now clicking on test/query, we get model's firmware version=10EC, Model type XB24, Serial Number= 13A20040B2EB5A. This shows testing of xbee module completed successfully. Similarly we checked second X-bee module. To test communication between your X-Bee's we need to connect second X-Bee to a computer as well. That means doing the "Add device" one more time.

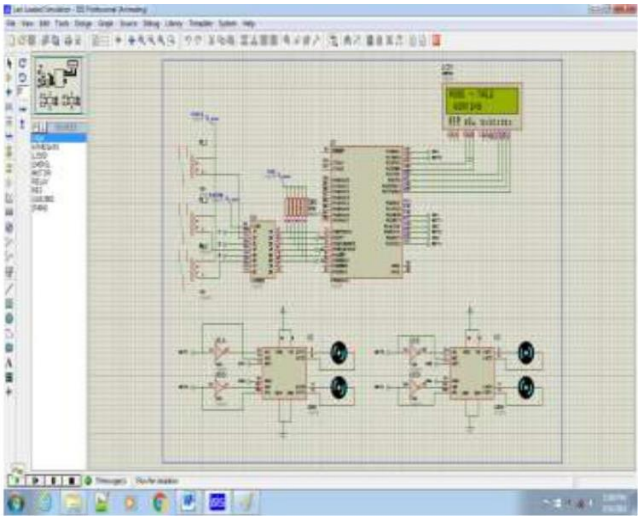

Fig -7: Simulation Diagram with Result

4.1 Configuring Networks

Most of the X-Bee configuration settings come down to controlling which other X-Bees are shown in fig.8. There are a few levels to X-Bee networks. First, there's 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.

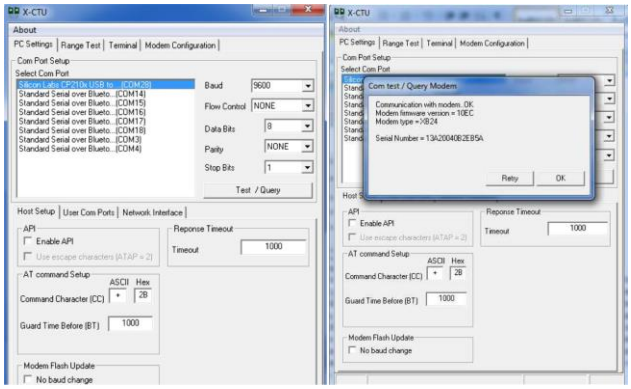

Fig -8: X-bee Software GUI with Module Testing Circuit

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 65536 possible ID's, there's 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.

5. EXPERIMENTAL SETUP

Following fig.9 shows experimental setup which consists of transmitter i.e. glove mounted on human palm with flex sensors & receiver which is robot manipulator arm. This setup shows receiver is following movement of transmitter.

Fig -9: Experimental Setup

CONCLUSION

Gesture based interfaces allow human computer interaction to be in a natural as well as intuitive manner. This paper discussed hardware and software co-design of robotic arm controller using DC motors employing microcontroller ATMEGA16.The robotic hand has been designed to meet all of the original specifications of the project. The fingers are allowing for full motion of the hand. Observations show that the project produces the required motion of the fingers. Such type of hand gesture controlled robotic arm is mostly useful for Industrial, Medical & Military applications. This type of the hand gesture technology can be used where the humans are unable to sustain in the difficult or harsh environments. This might reduce some of the labor that is used in industry and also the life risk factor.

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BIOGRAPHIES

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