Gesture Controlled Robot for Remote Applications

Harshit Goel
B. Tech Student
Department of Electronics
Maharaja Agrasen College University of Delhi Delhi-110096

Abstract— The paper describes robustness of Sensors based Gesture Controlled Robot which is a kind of robot that can be controlled by our hand gestures rather than an ordinary old switches or keypad. In future there is a chance of making robots that can interact with humans in a natural manner. Hence my target interest is with hand motion based gesture interfaces. An innovative formula for gesture recognition is developed for identifying the distinct action signs made through hand movements. An Acceleration Sensor was used to carry out this and also a Flex sensor for convinced operation. For communication between hand and robot XBee, radio module has been used which has a significant transmission range, consumes low power and has multiple advantages over conventional RF or Bluetooth transmission. In order to full-fill our requirement a software program has been written and executed using a microcontroller on the robot. Gestures control robots can extensively be employed in human non-verbal communication. They allow to express orders (e.g. “stop”), mood state (e.g. “victory” gesture), or to transmit some basic cardinal information (e.g. “two”). In addition, in some special situations they can be the only way of communicating, as in the cases of deaf people (sign language) and police’s traffic coordination in the absence of traffic lights, a real-time continuous gesture recognition system for sign language Face and Gesture recognition. Upon noticing the results of experimentation proves that our gesture formula is very competent and it also enhances the natural way of intelligence and is also assembled in a cheap simple hardware circuit.

Key words: Gesture Controlled Robot, Remote Applications, XBee Radios

I. Introduction

Technology today is imbibed for accomplishment of several tasks of varied complexity, in almost all walks of life. The society as a whole is exquisitely dependent on science and technology. Technology has played a very significant role in improving the quality of life.

The increase in human machine interactions in our daily lives has made user interface technology progressively more important. Physical gestures as intuitive expressions will greatly ease the interaction process and enable humans to more naturally command computers or machines.

Robots are becoming increasingly useful on the battlefield because they can be armed and sent into dangerous areas to perform critical missions. Controlling robots using traditional methods may not be possible during covert or hazardous missions. A wireless data glove was developed for communications in these extreme environments where typing on a keyboard is either impractical or impossible. This paper reports an adaptation of this communications glove for transmitting gestures to a robot to control its functions. Novel remote control of robots has been an active area of research and technology, especially over the past decade. For example, a wearable, wireless tele-operation system was developed for controlling robot with a multi-modal display [3]. Remotely controlled robots have been used in environments where conditions are hazardous to humans.

Gestures were used to control a Firebird V robot [1]. Other proposed applications of recognizing hand gestures include Landmine Detection, gesture recognition to control a television set remotely [2], enabling a hand as mouse, and using hand gestures as a control mechanism in virtual reality. The system has potential uses such it act as a vocal tract for speech impaired people by recognizing sign language and converting it to human voice. In our work, an accelerometer based recognition system which can recognize eight hand gestures in 3-D space is built.

II. Technical Aspects of Project

The main aspect of this project was establishing a proper communication channel between transmitter and receiver for which I have used XBee radios. For recognizing the human hand gesture ADXL 335 Accelerometer [8] has been used along which simple flex sensors. All these components were soldered on a general purpose circuit board which was mounted on a glove for giving it a user friendly appearance. A brief description and working of all the components is given below.

III. Accelerometer

The ADXL335 is a complete 3-axis acceleration measurement system. The ADXL335 has a measurement range of ±3 *g* minimum. It contains a polysilicon surface-micro machined sensor and signal conditioning circuitry to implement open-loop acceleration measurement architecture. The output signals are analog voltages that are proportional to acceleration. The accelerometer can measure the static acceleration of gravity in tilt-sensing applications as well as dynamic acceleration resulting from motion, shock, or vibration.

The ADXL335 uses a single structure for sensing the X, Y, and Z axes. As a result, the three axes’ sense directions are highly orthogonal and have little cross-axis sensitivity. [8]

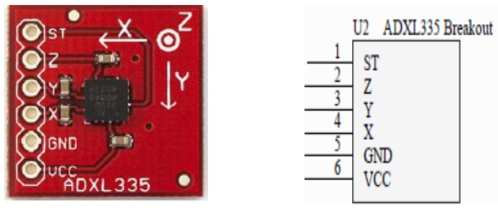


Fig. 1: ADXL335

A. Flex Sensor

The Flex Sensor patented technology is based on resistive carbon elements. As a variable printed resistor, 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—the smaller the radius, the higher the resistance value. It has a flat resistance of 25K ohms, resistance tolerance of ±30%, bend resistance of 45K to 125 K ohms and power rating of 0.5W continuous and 1W peak. [5]

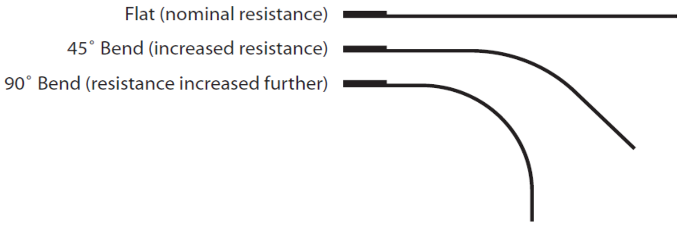
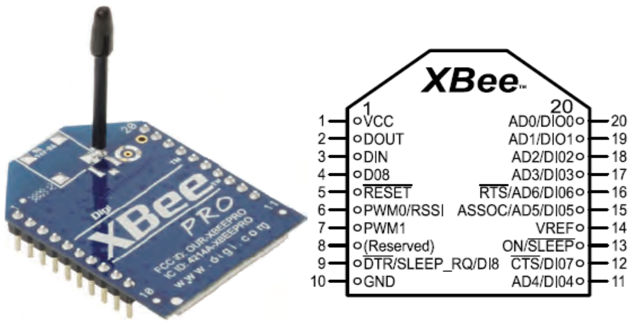


Fig. 2: Flex Sensor [5]

B. XBee

The two main wireless standards mostly used for wireless sensor networks are ZigBee and IEEE 802.15.4 [9]. Due to low power consumption, simple network deployment, low installation costs and reliable data transmissions, these two standards are mainly preferred over Wi-Fi and Bluetooth. For this study, we will only analyze the performance analysis of a wireless sensor network using the ZigBee standard. ZigBee is built on top of the IEEE 802.15.4 standard, operating in an unlicensed band of 2.4 GHz with a data transfer rate of 250 kbps with a working rage of 1 mile with a power consumption of 215mA @ 3.3V. In terms of networking capability, ZigBee protocol supports three types of communication topologies such as point-to-point, point-to-multipoint and mesh topology. ZigBee enabled devices operate with low duty cycle, hence providing longer battery life which makes it the most widely used devices for a wireless sensor network [2].

I have used the XBee ZB S1 modules which are ZigBee-complaint wireless sensor networking devices developed by Digi International, Inc. Each XBee ZB module has the capability to directly gather sensor data and transmit it without the use of an external microcontroller. By excluding the external micro- controller, the overall size of the project can be reduced. This is essential when creating sensors that need to be inconspicuous. By using XBee alone, it can minimize weight which is an important factor for systems such as Body Sensor Networks or wearable [3]. Omitting an external microcontroller also reduces power consumption which is a critical advantage for wireless systems that run on batteries and saves money. Furthermore, to reduce energy consumption and to increase the network lifetime, active and cyclic sleep modes for a battery-powered sensor node have been analyzed.



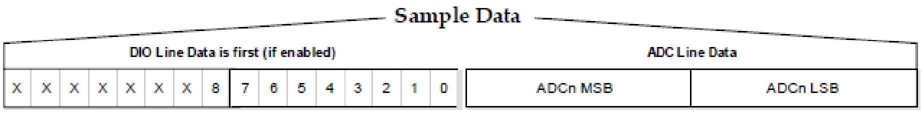
[9]

Fig. 3: XBee-Pro Module and Pin outs

1) I/O Data Format

The XBee/XBee-PRO RF Modules support ADC (Analog-to-digital conversion) and digital I/O line passing.
To enable ADC and DIO pin functioning: [9]

For ADC Support:	Set ATDn = 2
For Digital Input support:	Set ATDn = 3
For Digital Output Low support:	Set ATDn = 4
For Digital Output High support:	Set ATDn = 5



[9]

Fig. 4: I/O Data Format

IV. SYSTEM DESIGN MODEL

A. Hardware System Design

In this case we have two sides one is transmitter side and other one is receiver side and the main thing is that there should be no physical connection between transmitter and receiver, so in order to fulfill this demand a completely wireless radio transmission was used with the help of XBee radios.

B. Transmitters Section

The main work of transmitter section here is, to properly record gestures and successful transmitting them to receiver's end.
To record gestures an accelerometer has been used which depending upon the change in gravitational acceleration values gives out some analog voltages on x, y or z pins. These voltages are then fed to ADC lines of XBee and then rest of the work is done by XBee itself.

XBee has six programmable ADC/DIO lines which can be used to connect six analog devices (like sensors) to it. It also has a Vref pin which was shorted with Vcc pin to give it a reference voltage of 3.3V. It outputs a ten Bit Digital Data after converting analog value to digital which were directly transmitted to receiver. A 'c' code was burned into microcontroller to decode this packet and process this information.

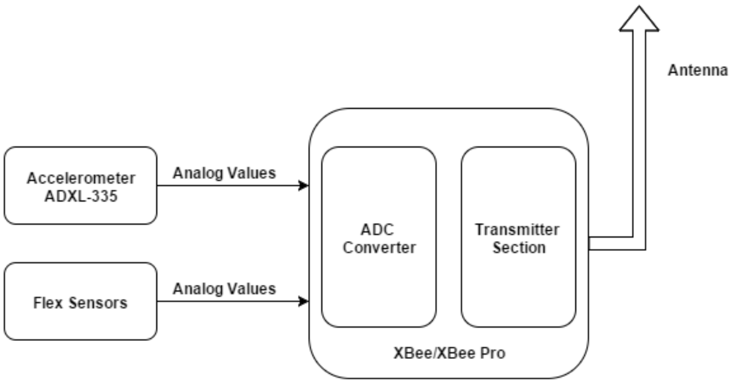


Fig. 5: Transmitter

C. Receiving Section

The below mentioned block diagram indicates the receiver section. The transmitted data by the transmitter is received by the XBee receiver and the serial data is given as the microcontroller which consists of a predefined program to fulfill our task, depending upon the data received the controller generates some signals to the motor driver LED’s buzzer’s etc., here the purpose of the motor driver is to drive the motors and here LED’s and buzzer are used for some specific indications. Various types of modules like sharp sensor, proximity sensors are embedded on Firebird V [1]. The Gripper is also controlled by the microcontroller depending upon the ADC values of flex sensor, in microcontroller a suitable 'embedded c’ program is written which after executing the input data takes all required actions.

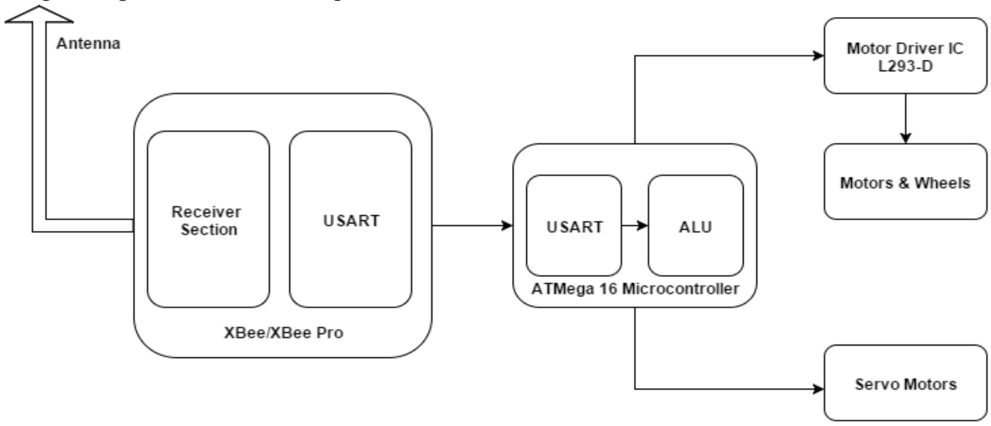


Fig. 6: Receiver

V. SOFTWARE SYSTEM DESIGN

For transmitter's side XBee was programmed using X-CTU software by DIGI Elec.
As the XBee communicates through a UART, you have to set the right baud rate, parity mode. The default factory settings for serial communication with the XBee are:

- Baud rate: 9600
- Flow control: none
- Data bit: 8
- Parity: none
- Stop bits: 1

AT Command	What Command stands for	What Command does	How to use the Command
+++	Enter AT Command mode		Type Command and wait 3 seconds, do not hit the enter key. If you wait 10 seconds without typing anything the terminal will drop out of Command mode.
AT	Attention	XBee should reply with OK	Type Command, if there is no OK response try reentering AT Command Mode.
ATID	Personal Area Network ID	Returns PAN ID # or sets PAN ID #	To check XBee's PAN ID # type the Command. To set XBee's PAN ID # type the command. PAN IDs are represented in hexadecimal.
ATSH/ATSL	64-Bit Address (or Serial #) distinct to each XBee unit	Type ATSH to return the upper half of your XBee's Address. Type ATDL to return the lower half of your XBee's Address. The Address is split into two sections because it will not fit in one. Addresses are represented in hexadecimal.	
ATDH/ATDL	XBee Destination Address (or Serial #)	Similar to command above the Address is split into two sections and represented in hexadecimal. Type just the command to read the Address of the other XBee the unit is trying to communicate with. To set the destination Address of an XBee type the command followed by the corresponding section of the destination Address you are setting for the XBee.	
ATCN	Command Null	Use this Command to drop out of Command mode.	
ATWR	Write	Use this Command to write the configuration you have created in the AT Command mode to the firmware. This effectively saves the configuration you have created to the XBee. If you do not use this AT Command the XBee will revert to previous settings when it is disconnected,	
ATMY	My ID	Use this Command to display the XBee's 16 bit Address in non-hexadecimal form.	
ATD0...ATD7	I/O Pin configuration	Sets the configuration of I/O pins 0 through 7.	These two Commands have a variety of settings; follow the Command with the numbers below for the purposes listed beside them. 0 : Disables I/O on that pin 1: Built in function, if available on pin 2: Analog input, only pins D0 – D3 3: Digital Input 4: Digital Output, LOW (0 volts) 5: Digital Output, HIGH (3.3 volts)
ATP0...ATP1	I/O Pin configuration	Sets the configuration of I/O pins 10 and 11.	

[6]

Receiver's end XBee receives this data and decodes the packet as:

- 7E 00 10 83 12 34 27 00 02 06 00 01 FD 01 FF 01 FE 01 FF A0
- 7E 00 10 83 12 34 27 00 02 06 00 02 A0 00 12 01 A7 01 92 18
- 7E 00 10 83 12 34 27 00 02 06 00 01 35 03 F1 01 5E 02 0F 6D

Byte Count	Field Value(Hex)	Description	Data Type
0	7E	Start Delimiter	Byte
1:2	0010	Length of Packet	Word
3	83	API Identifier	Byte
4:5	1234	Source Address	Word
6	27	RSSI PWM Byte Received Signal Strength (dBm) of last received packet.	Byte
7	00	Option Byte 0x01 - Packet was acknowledged. 0x02 - Packet received as a broadcast. 0x04 - Packet received on broadcast PAN (XBEE only).	Byte
8	02	Samples per Channel	Byte
9	06	-----	Byte
10	00	-----	Byte
11:12	01FD	ADC 0 (MSB + LSB) Sample 1	Word
13:14	01FF	ADC 1 (MSB + LSB) Sample 1	Word
15:16	01FE	ADC 0 (MSB + LSB) Sample 2	Word
17:18	01FF	ADC 1 (MSB + LSB) Sample 2	Word
19	A0	Checksum 0xFF minus 8-bit sum of bytes between the length and checksum fields	Byte

*Here I have used my Transmitter XBee having 2 ADC channels (ADC 0 & ADC 1) enable and each sampling 2 data.

**The analog values from Sensor are continuously changing and hence the digital output from UART.

The bytes (11:12, 13:14, 15:16, and 17:18) are first averaged and then merged into a 10 bit data and stored into an array and from that array these data are sent to their respective functions to be processed upon.

Thresholds for each axis are stored in program with which this received data is compared and further actions are taken based upon that result.

VI. LIMITATIONS

- Working range decreases as battery voltage decreases.
- Gestures are quite sensitive.
- Less stabilization.

VII. FUTURE SCOPE

- To control a drone bot with the help of Gesture for Landmine Detection.
- To be used as firefighting robot in remote areas where human help cannot be reached.
- To implement this gesture technology such that voice impaired people could use their gestures to be converted to voice.

VIII. CONCLUSION

We have proposed a fast and simple algorithm for hand gesture recognition for controlling robot. We have demonstrated the effectiveness of this computationally efficient algorithm on real images we have acquired. In our system of gesture controlled robots, we have only considered a limited number of gestures. Our algorithm can be extended in a number of ways to recognize a broader set of gestures. The gesture recognition portion of our algorithm is too simple, and would need to be improved if this technique would need to be used in challenging operating conditions. Reliable performance of hand gesture recognition techniques in a general setting require dealing with occlusions, temporal tracking for recognizing dynamic gestures, as well as 3D modelling of the hand, which are still mostly beyond the current state of the art.[4]

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