International Journal of Innovative Research in Electronics and Communications (IJIREC)
Volume 2, Issue 5, July 2015, PP 55-62
ISSN 2349-4042 (Print) & ISSN 2349-4050 (Online)
www.arcjournals.org

Hand Gesture Initiated Motor Operations for Remote Robot Surveillance System using Raspberry Pi Processor on a ZigBee Communication Link

[1]Kausthub N P, [1]Rounak S

[1]Department of Telecommunication Engineering
B.N.M. Institute of Technology
Bangalore, India
kausthub008@gmail.com
rounaksiddaiah@gmail.com

[2]Bhakthavathsalam R, [2]Gowranga K H, [2]Saqquaf S M

[2]Supercomputer Educ. and Res.Centre
Indian Institute of Science
Bangalore, India
bhaktha@serc.iisc.ernet.in
gowranga@serc.iisc.ernet.in
saqquaf@serc.iisc.ernet.in

Abstract: *Embedded Robotic solutions are best preferred for industries in increasing productivity and efficiency by automating processes and removing human dependencies. This paper focuses on automated surveillance of supervision with artificial intelligence solutions that improve productivity, enhance comfort, and ensure safety and security in the industrial premises by continuously capturing video footage. The movement of gestures can be used to interact with technology like computers, using touch or multi-touch or physical movement detection and visual motion. A robot has been designed which can be used for surveillance purposes by controlling it with hand gestures. Further a 3 axis sensor is used to sense the gestures and give input to an Arduino which in turn gives the Raspberry Pi commands to move the robot in different directions using the ZigBee communication link. A webcam is used to take the live feed and the streamed video is accessed in a Wi-Fi environment.*

Keywords: *Accelerometer, Gesture Recognition, ZigBee Communication, surveillance, Raspberry pi and Arduino Uno.*

1. INTRODUCTION

A Hand gesture controlled robot is a kind of robot which can be controlled by hand gestures instead of using buttons. The user needs to wear a small transmitting device on his hand. In this application, the sensor used is an accelerometer. Movement of the robot in a specific direction is controlled by specific gestures or movements made by the hand. The transmitting device includes a microcontroller called Arduino to control and assign proper levels of input voltages from the accelerometer .The microcontroller IC which is used to encode the 8 bit data is transmitted by an RF Transmitter ZigBee module.

At the receiving end, an RF Receiver ZigBee module receives the encoded data which is decoded and processed by a Raspberry Pi microprocessor. This data is then passed onto a motor driver to rotate the motors in the robot and there by follows commands initiated by the user's hand movement.

1.1 Gesture Generation and Recognition

Gesture recognition, a fairly young technology is used in this robotic application. Gestures are achieved by actions of the hand [1]. The accelerometer sensor measures the tilt and direction intended by the hand. We make use of this technology to determine and interpret direction commands. The micro controller Arduino Uno is used to interpret analog voltage values from 0-5V[2]. These voltage values are received in the digital format from 0-1024 in the serial monitor of the Arduino IDE, which is then calibrated to the users command according to the user'smotivation.

1.2 Objective

To design and implement a ground base robot, which is controlled by hand gestures and uses internet (Wi-Fi module) to live stream the video, with limited range(300ft) as the communication is through ZigBee module.

1.3Application

- Gesture controlling is very helpful for handicapped and physically disabled people to achieve certain tasks, such as driving a vehicle.
- Gestures can be used to control interactions for entertainment purposes such as gaming to make the game player's experience more interactive or immersive.
- Surveillance robot has lot of indoor applications in warehouses, shopping malls, hospitals and large single floor buildings.
- It can also be used in power plants, war fields, harbors, airports and construction sites for inspections.

2. HARDWARE/SOFTWARE USED

2.1 Hardware

2.1.1 Raspberry Pi Microprocessor

Raspberry pi is a Credit-card sized mini microprocessor that plugs into any monitor (HDMI)[3]. A keyboard and mouse can be interfaced with the microprocessor with USB 2.0. This microprocessor has a SD slot extendable up to 32 GB in which OS can be stored and booted accordingly, we have used Raspbian OS.Ethernet Port or a USB Wi-Fi(Wi-Pi) adaptor is used to connect to the Internet [4]. GPIO pins allow us to control and interact with real world sensors or component in this case motor driver (H-Bridge), ZigBee, etc.

2.1.2 Arduino Uno

The ArduinoUno is a microcontroller board based on the ATmega328 [5]. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs. The accelerometer is connected to the analog input pins A1, A2, A3, etc. Pin0 and Pin1 are RX and TX pins, which are connected to the[1]TX and RX respectively of the transmission ZigBee. The serial data with baud rate of 9600bps is transmitted with these ZigBee. Provision for a 5v DC source and GND pins Connectivity is available from the microcontroller which will power the ZigBee.

2.1.3 ZigBee Communication Link

In this application, 2 ZigBee[6](version S2)modules (Transmissions and receiver respectively), low power digital radios based on an IEEE 802 standard for personal area networks are used. ZigBeeis a low cost, low power, wireless mesh network standard, has a defined rate of 250 Kbit/s. With a specification for a suite of high level communication protocol, ZigBee is best suited for irregular or periodic data or a single signal transmission from an input or a sensor device.The low cost allows the technology to be widely used in monitoring and wireless control applications. Every network must have one coordinator device. In star networks, the coordinator must be the central node. Both, trees and meshes allow the use of ZigBee routers to extend communication at the network level.

Table 2.1 *ZigBee Communication Standards*

Band	868 MHz	915 MHz	2.4 GHz
Region	EU, Japan	US	Worldwide
Channels	1	10	16
Data rate	20 kbps	40 kbps	250 kbps

2.1.4 Accelerometer

The ADXL335[7] is a small, thin, low power, complete three axesaccelerometer with signal conditioned voltage outputs, all on a single monolithic IC. The product measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of [6]gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The user selects the bandwidth of the accelerometer using the CX, CY, and CZcapacitors at the[2] XOUT,

YOUT, and ZOUTpins. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1,600 Hz for X and Y axes,and a range of 0.5 Hz to 550 Hz for the Z axis.

2.1.5 Other Components

5V DC motors(Torque-4.9mNm/50g.cm, 60 RPM), chassis, Wi-Pi (Wi-Fi adaptor), laptop, monitor and web cam

2.2 Software Requirements

2.2.1 Xbee X-CTU Software

X-CTU is a XBee [8]configuration software.It makes communicating with XBee's very easy and provides a interface to modify all the modules settings. While configuring the ZigBee, the unique id or the address of transmission ZigBee is fed to the recevier ZigBee and vice versa.The figure shows the communication path between to three ZigBee radios, and forms a mesh network using Xbee series 2 modules.

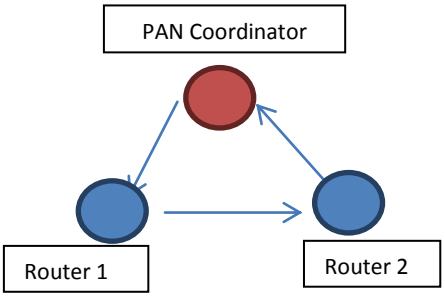

FIG 2.1 *Xbee Communication Interaction Block Diagram*

2.2.2 RaspbianWhezzy OS

Raspbian is a free operating system based on Debian optimized for the Raspberry Pi hardware[3]. Raspbian provides more than a pure OS: it comes with over 35,000 packages and pre-compiled software bundled in a nice format for easy installation on Raspberry Pi. Since the OS has many pre-installed packages it becomes very easy to interface Wi-Fi adaptors mouse, keyboards etc. We make use of Python [9]language to write the code and interface it with the GPIO pins of the raspberry pi. Instructions are to give and receive command through these pins.

2.2.3 Arduino Programming

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board[5].The hand gesture analyzing algorithm is written in this platform which is then uploaded to the microcontroller [1].

2.2.4 Putty Configuration

Putty is required to connect to Raspberry pi server from a windows or linux workstation using a Secure Shell (SSH) client program [4]. The SSH client is a program that facilitates secure text-level access to a UNIX shell.This is a very helpful tool as it allows multiple users to interface and make correction at the same time for the same code by logging on to same Raspberry pi server.

3. DESIGN AND IMPLEMENTATION

In fig 3.1, the block diagram shows two major parts: hand gesture controller and surveillance robot. The hand gestures determined by accelerometer use 3 degrees of freedom namely pitch, yaw and roll. The data is analyzed and interpreted using an Arduino code which is uploaded to an Arduino Uno microcontroller. Asynchronous serial data is transmitted from the Arduino to the Raspberry Pi using a wireless communication link with two ZigBee, router ZigBee at the transmission end and coordinator ZigBee at the receiving end. The Raspberry Pi processes the received serial data and drives the DC motor. Webcam mounted on the Robot captures the streaming video and uploads it to the local sever using the Wi-Pi adaptor. This live streaming of the video can be viewed in the computer or mobile by addressing the particular IP[10].

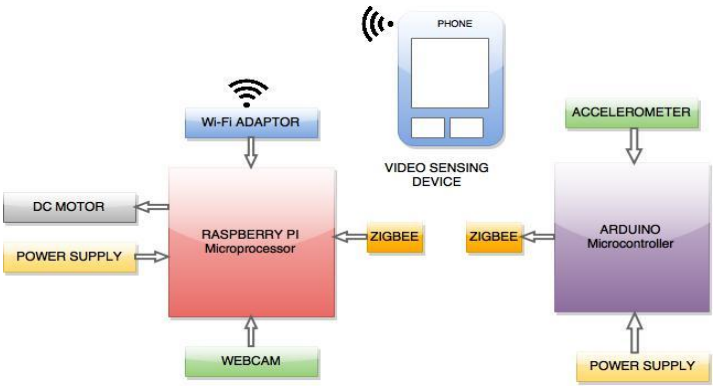

FIG 3.1 *Block Diagram*

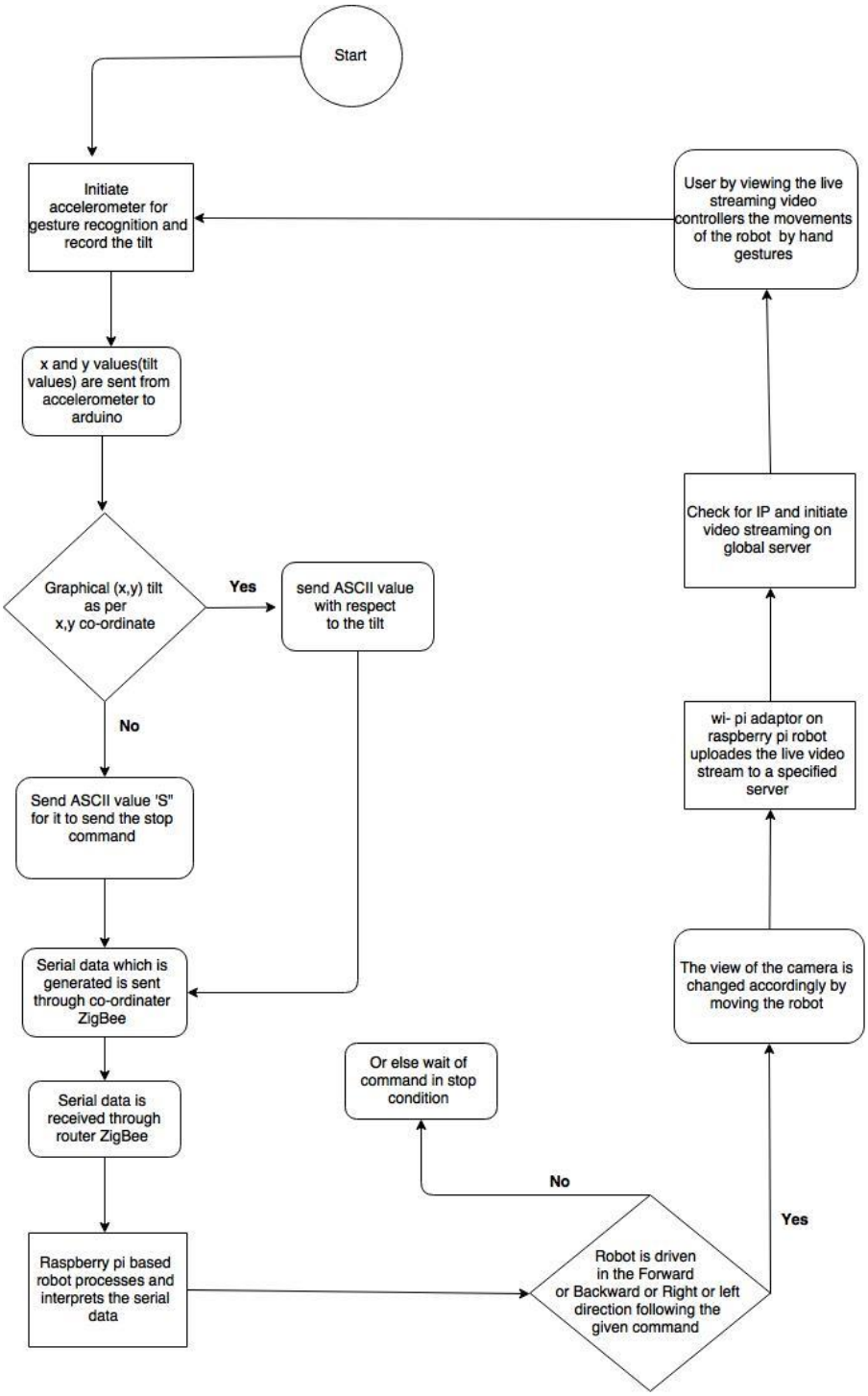

FIG 3.2 *Flow chart*

3.1 Control Signal Generation

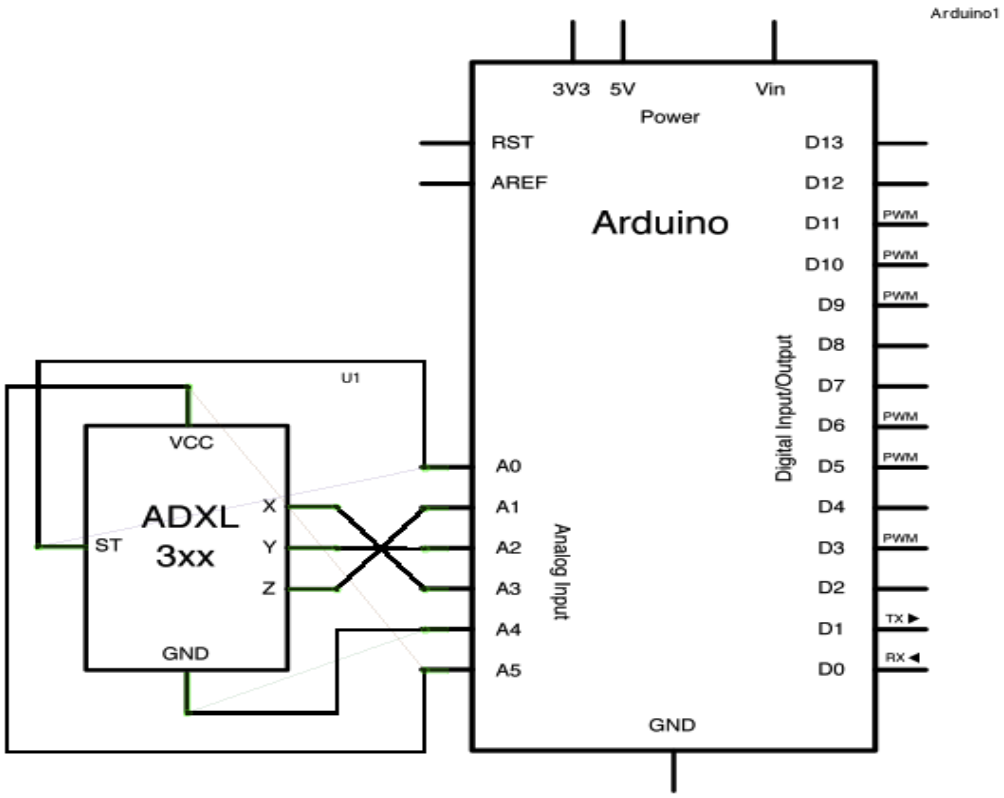

FIG 3.3 *The Hand Gesture Remote pin diagram*

The output of ADXL335 accelerometer is an analog voltage between 0 to 5 volts [7]. These voltage values are interpreted in the range 300 to 800 units for each axis. The deviation from the center value determines the tilt with respect to the axis considered. In this paper only X and Y axis are considered for navigation [2].

The interpreted values for different directions are as follows

Table 3.1 *Directions and Their Respective Calibrations*

Directions	Value of X	Value of Y
Front	X>480	Y>100
Back	X<430	Y>100
Right	X>100	Y>400
Left	X>100	Y<360

The above condition gives the distinct directions to follow. Whenever these conditions are satisfied serial data ‘F’-forward, ‘B’-backward, ‘R’-right,’ L’- left and ‘S’-stop are transmitted using UART communication through the readily available Tx and Rx pin on an Arduino board [3]. These conditions are written in an Arduino IDE and uploaded to the Arduino board to implement the gesture recognition part of the paper.

3.2 Robot Navigation

To execute the application it requires the serial ports to be configured according to the standard 26 pin Raspberry Pi processor.In the Raspbian Wheezy OS there is a terminal available in which the receiver code is written in python scripting language inorder to interprit and decode.Sending and receiving serial data is one of the most challenging aspect of our application which is made possible by serial ports available in Raspberrt Pi [10].

4. RESULTS AND DISCUSSIONS

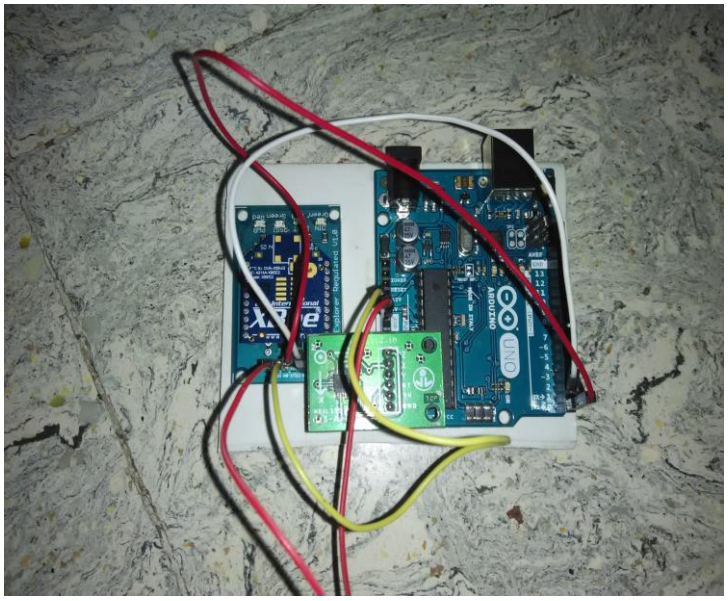

FIG 4.1*The Hand Gesture Remote Device*

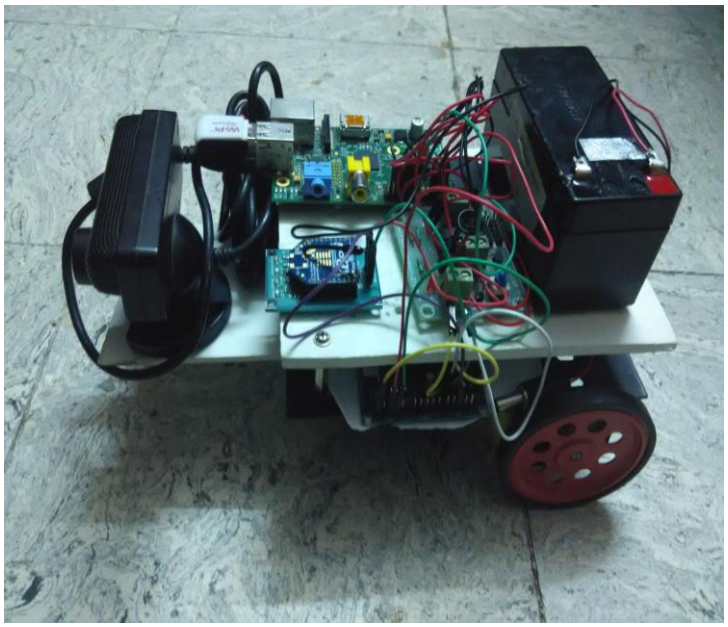

FIG 4.2 *TheSimulated Construction of the Robot*

Robot shows adequate response whenever hand is moved and it moves in the intended direction with ease.The robot only moves when the accelerometer is tilted in a specific direction. The valid movements are as follows: [1]

Table 4.3 *Relation between Direction and Remote's Orientation*

Direction	Accelerometer Orientation
Forward	+y
Backward	-y
Right	+x
Left	-x
Stop	Rest

The range of ZigBee communication achieved is 300 ft.The video is successfully received with feed from the surveillance Robot in the Wi-Fi environment of 300ft. 360 degrees of rotational freedom is achieved, the view of the camera can be adjusted at will, by moving the Robot.30 Fps is obtained for generating a HD viewing of the video footage on the user's browser by specifying the local IP address.

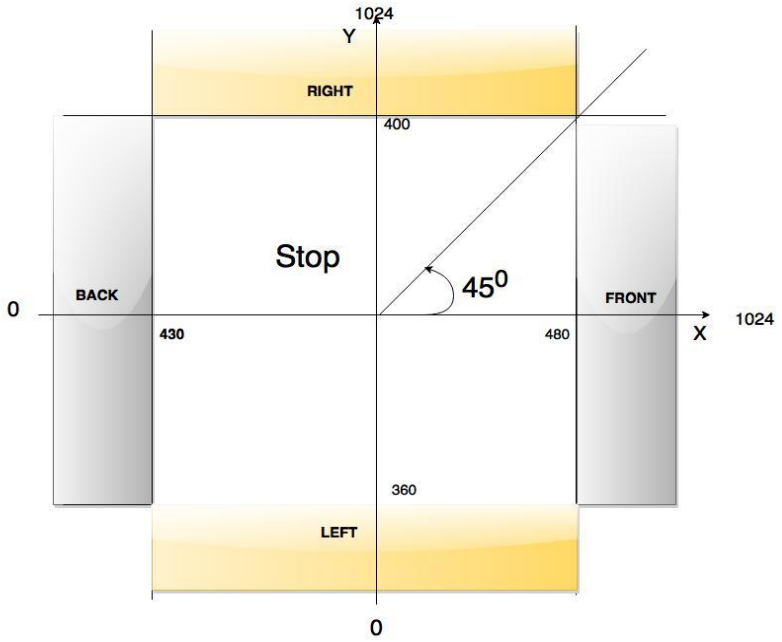

Fig 4.3*Graph and Calibration of Navigation*

5. CONCLUSION

The design of a remote surveillance system capable of capturing video and transmitting the same was clearly put forth in this application. An autonomous robot capable of recognizing commands given by simple hand gestures was demonstrated. This gesture recognition part of the paper was established with a help of microcontroller and an accelerometer. The wireless communication link was established using two ZigBee. The Raspberry Pi based robot recognizes commands and navigates accordingly, rendering it as a novel and a valuable in any remote surveillance implementation.

5.1 Scope for Future Work

The cost incurred for surveillance by industries is expensive. Monitoring the employees and the facility is of the primary concern for the industry. The common vogue is to use CCTV cameras. Cameras are indeed important in certain places at certain times but not always. This robot is equipped with a camera which achieves surveillance at the will of the user. The applications are not limited to surveillance.It can be deputed in a radiation prone areas with few add on sensors. The extent of a chemical leak in the industry can be monitored and certain emergency evacuation procedures can be assisted by this robot without any loss or harm to human life. By modifying the dynamics of the Robot and increasing maneuvering techniques, this Robot can be used in military applications. In certain exploration missions where human access is at risk this Robot can be sent as a scout, inspecting the area and sending back the video information,which is vital information for saving lives or avoiding risk. The resolution of the motor movements can be changed or modified according to the specific application. Raspberry Pi processor has a multiple number of free GPIO pins which can be connected to a number of sensors according to the robot's application.

ACKNOWLEDGEMENTS

The authors sincerely thank the authorities of Supercomputer Education and Research Center, Indian Institute of Science, Bangalore, India for the encouragement and support during the entire course of this work.

REFERENCES

[1]. http://ablab.in/accelerometer-based-hand-gesture-controlled-robot-with-avr-atmega32-microcontroller/

[2]. http://ablab.in/3-axis-accelerometer-sensor-interfacing-with-avr-atmega32-microcontroller/

[3]. Matt Richardson and Shawn Wallace, "*Make: Getting Started With Raspberry Pi"*, 2nd ed. Maker media. Inc. October 2014.

[4]. www.raspberrypi.org

[5]. www.arduino.cc

[6]. Ariful Islam Bhuyan ,Tuton Chandra Malick, "*Gyro-Accelerometer based Control of a Robotic Arm using AVR Microcontroller"*. IEEE The 9th International Forum on Strategic Technology, October 2014 PP 409-413.

[7]. http://bildr.org/2011/04/sensing-orientation-with-the-adxl335-arduino/

[8]. www.libelium.com/devolepment/waspmote/documentation/x-ctu-tutorial/

[9]. Simon Monk Programming the Raspberry Pi "*Getting Started With Python"*, 2nd ed. McGraw Hill.Ch 3 PP 25-39.

[10]. Sneha Singh, PradnyaAnap ,YogeshBhaigade, Prof .J.P.Chavan , "*IP camera Video Surveillance Using Raspberry Pi*", International Journal of Advanced Research in Computer and Communication Engineering. Vol4,issue 2 February 2015 PP 326-328.

AUTHORS' BIOGRAPHY

Mr. Kausthub NP, received his B.E. degree in Telecommunication Engineering from Visvesvaraya Technological University, India. He is presently undergoing the Master's program in Embedded and VLSI systems in Manipal University, India. His areas of interests include Robotics, Industrial Automation and Image Processing. He is a student member of Robotics Club, B N M Institute of Technology, Bangalore.

Mr. Rounak, obtained his B.E. degree in Telecommunication Engineering from Visvesvaraya Technological University, India. He gained work experience from Robofission, Pvt, Ltd., Bangalore. He earned accreditation from International Aerial Robotics Organization. He is now pursuing his research work in Robotics. His major research interests are Wireless Communication, Image Processing and Aviation Technologies.

DR. R Bhakthavathsalam is presently working as a Principal Research Scientist in SERC, Indian Institute of Science, Bangalore. His areas of interests are Pervasive Computing, Wireless Networks and Electromagnetics with a special reference to exterior differential forms. Author held the position of Fellow of Jawaharlal Nehru Centre for Advanced Scientific Research during 1993 -1995. He is a Member of IEEE Communication Society, ACM and CSI.

Mr.Gowranga K H is currently working as Senior Scientific Assistant in Supercomputer Education and Research Center, Indian Institute of Science, Bangalore. He is actively involved in maintaining the Web and Mail servers in the campus. His research interests include Wireless Networks, Webmail Systems and Digital Communication.

Mr. Saqquaf S M graduated in Electronics and Communication Engineering and did his post graduate studies in Computer Science and Computer Management.Presently working as Senior Technical Officer, looking after overall Infrastructure and coordinating Computer System Admin Training program at SERC. His fields of interests are Power Management, Captive Power Generation, Power Auditing, UPS Systems and Campus Communication Network.