Wireless Cursor Control by Gesture Recognition

Dhaval Waghulde*, Priyanka Zambre**, Girish Baj*, ManaalMukhtar**
*Electronics Telecommunication, College of Engineering Pune, Pune, India

Abstract

For body-borne computing to become more widely accepted, the associated Human-Computer Interface must move past today's mechanical devices such as keyboard, mouse and other handheld interfaces to allow the users to specify input through their body. Accordingly, there is an invention of a body-borne system which can track hand gestures with an accelerometer to control the cursor. This project aims to deliver the maneuver of mouse pointer and performs various operations using gesture recognition and wireless communication. This paper describes an alternative to interact with computer, for those who do not want to or are not able to use conventional HCI (human compute r interface). An accelerometer device is used to detect the position in X, Y direction caused by movement of device mount on the wrist, as referred to acceleration due to gravity. Accelerometer output is converted to digital form with analog to digital converter of microcontroller and it is further connected to the 433 MHz RF module transmitter which is used to transmit the wireless signal to the RF module receiver. Receiver receives signal from transmitting end and which is transferred to microcontroller, then to PC, which uses TTL to RS232 line driver to interface controller to the PC. In PC, MATLAB code for cursor control in response to accelerometer movement is developed. This simple low cost, low power inertial sensor based mouse with wireless capability offers ease of use.

Keywords: *Accelerometer, Gesture Recognition, RF module, cursor control, microcontroller*

I. INTRODUCTION

In today's digitized world, input technologies seem to cause a major bottleneck in performing some of the complex tasks, limiting utilisation of some of the available resources and restricting the application use, they work with the length of the connecting cable and require a surface to work on. Computer being used by many people in their work or spare time, special input and output devices have been designed to ease the communication between computers and humans. Every new device is designed to make computer more intelligent to add to the communication ease with the humans. One such commonly used input device is a wireless mouse. But even in the case of a wireless mouse the requirement of surface is still present.

HCI is one of the important area of research where people try to improve the computer technology to match with the increase in processing speeds. Gesture is a natural human communicating capability evolved from eras but shaped by technology today. It stands out in its own way as it allows one to act in his own environment as well as to retrieve information from it.

The research activity on gesture based user interface (UI) has been proliferating since the last decade. These technologies gained popularity as they can be applied in various fields such as web services, smart home systems, robot manipulation, and games etc. Gesture based interaction takes into consideration the continuity and dynamics of the user movements, instead of only the discrete information from these movements. They accept input in form of taps, swipes and various hand and arm motions. These are a growing array of alternate input devices that allow computers to acknowledge and interpret gestures as a means of input. The design implemented for wireless cursor control has been discussed in this paper.

II. BLOCK DIAGRAM

Block diagram can be divided into two parts: transmitter side and receiver side.

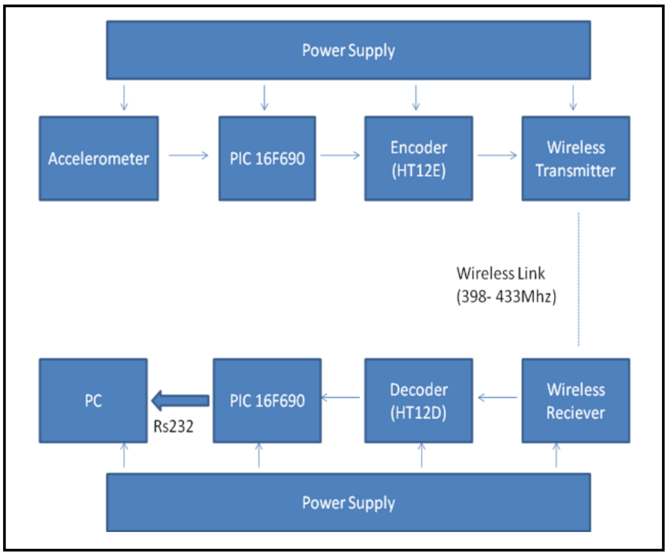

Figure 1. Block Diagram

Following cursor functions have been implemented in the design. These can be extended in future depending upon user requirement.

1. Right CLick
2. Left Click
3. Scroll Up
4. Scroll Down
5. Zoom In
6. Zoom Out

III. SYSTEM IMPLEMENTATION

A. *Transmitter*

The transmitter section is the wearable accelerometer glove which consists of the accelerometer ADXL335 for real time gesture recognition, a microcontroller for programming and a transmitter to transmit the processed data

Wireless transmission of data is established using a wireless RF transmitter-receiver pair operating at 433MHz. The transmitter gets the data to be transmitted from microcontroller transmits it to the receiver which gives it to the controller. The transmission occurs at a rate of 1kbps- 10 kbps. The transmitted data is received by a RF receiver operating on same frequency.

Protocol was followed while transmitting data. Format of this protocol is as below:

D	1	D	1	D	1	D	1	D

Figure 2. Protocol Format

Since the data is to be sent bit by bit, a detectable pattern is kept so that fist bit of data can be identified by receiver. This identifier is programmed such that it does not interfere with the regular data. The protocol format is such that after the detectable pattern, a byte of x acceleration is sent. Similarly y acceleration byte is sent and then special function byte is sent. This format ensures none of the data is lost and to have uniform control on cursor.

B. *Microcontroller*

The microcontroller PIC 16F690 is used on both the transmitter and receiver side. PIC 16F690 is a 20 pin IC. On the transmitter side, the controller is interfaced with the accelerometer and it gets the acceleration values for all the three axis on three different input channels. These analog signals are digitized using the 10-bit in-built ADCs and are given to the transmitter for transmitting at RF frequency of 433MHz.The Analog-to-Digital Converter allows conversion of an analog input signal to a 10-bit binary representation of that signal. This device uses analog inputs, which are multiplexed into a single sample and hold circuit. The output of the sample and hold is connected to the input of the converter. The converter generates a 10-bit binary result via successive approximation and stores the conversion result into the ADC result registers.The ADC voltage reference is software selectable to be either internally generated or externally supplied. The ADC cangenerate an interrupt upon completion of a conversion. This interrupt can be used to wake-up the device from Sleep.

On the receiver side, the controller receives the data from the receiver and simply passes on the data to the PC (Matlab) through UART. Same controller has been used on both the sides to maintain uniformity.

C. *Accelerometer*

The forces sensed by the accelerometer may be static or dynamic, static – like the constant force of gravity (useful for tilt sensing applications) and dynamic – caused by moving or vibrating the accelerometer. ADXL335, a 3-axis accelerometer is used in this project which gives an analog output. 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.ADXL335 complete, low-power 3-axis accelerometer measures dynamic acceleration (motion, shock, or vibration) and static acceleration (tilt or gravity) over a ±3 g range with 0.3% nonlinearity and 0.01%/°C temperature stability.

Self-Test on accelerometer was also performed to verify the accurate functionality of itLow power consumption of 350uA only.Capacitors were used at X, Y and Z outputs to limit bandwidths of the signal so that noise does not get accumulated in it. They act as low pass filters with internal IC resistors for anti-aliasing as well. Selected accelerometer bandwidth determines the measurable bandwidth

The sensor has characteristics of gaussian noise, statistical noise calculations were done to determine number of samples to be taken:

$$F(-3\text{ dB}) = 1/\left(2\pi\,(32\text{ k}\Omega) \times C(X, Y, Z)\right)$$

Temperature hysteresis of the sensor is very low (3mg over -25 to 70 C temperature range)Additional decoupling capacitors were used in power supply line along with ferrite bead to reduce errors caused due to noise.

D. *Encoder (HT12E)*

HT12E is an encoder integrated circuit of 2^{12} series of encoders with the operating voltage from 2.4-12V. They are paired with 2 series of decoders for use in remote control system

applications. It is mainly used in interfacing RF and infrared circuits. The chosen pair of encoder/decoder should have same number of addresses and data format. HT12E converts the parallel inputs into serial output. It encodes the 12 bit parallel data into serial for transmission through an RF transmitter. These 12 bits are divided into 8 address bits and 4 data bits.The transmitted signals are received by the receiver module placed away from the source of transmission.The system allows one way communication between two nodes, namely, transmission and reception. The RF module has been used in conjunction with a set of four channel encoder/decoder ICs. The encoder converts the parallel inputs (from the remote switches) into serial set of signals. These signalsare serially transferred through RF to the reception point.
Described below is the flowchart explaining the working of HT12E.

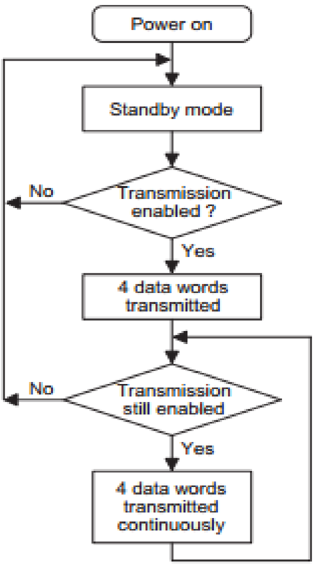

Figure 3. Flow Diagram Describing Working of HT12E Encoder

E. Decoder (HT12D)

The HT 12D ICs are series of CMOS LSIs for remote control system applications. HT12D is a decoder integrated circuit that belongs to 2^{12} series of decoders. This series of decoders are mainly used for remote control system applications, like burglar alarm, car door controller, security system etc. It is mainly provided to interface RF and infrared circuits. They are paired with 2^{12} series of encoders. The chosen pair of encoder/decoder should have same number of addresses and data format.Transmitter, upon receiving serial data from encoder IC (HT12E), transmits it wirelessly to the RF receiver. The receiver, upon receiving these signals, sends them to the decoder IC (HT12D) through pin2. The serial data is received at the data pin (DIN, pin14) of HT12D. The decoder then retrieves the original parallel format from the received serial data. When no signal is received at data pin of HT12D, it remains in standby mode and consumes very less current (less than 1μA) fora voltage of 5V. When signal is received by receiver, it is given to DIN pin (pin14) of HT12D. On reception of signal, oscillator of HT12D gets activated. IC HT12D then decodes the serial data and checks the address bits three times. If these bits match with the local address pins (pins 1-8) of HT12D, then it puts the data bits on its data pins (pins 10-13) and makes the VT pin high. An LED is connected to VT pin (pin17) of the decoder. This LED works as an indicator to indicate a valid transmission. The corresponding output is thus generated at the data pins of decoder IC.A signal is sent by lowering any or all the pins 10-13 of HT12E and corresponding signal is received at receiver's end (at HT12D). Address bits are configured by using the by using the first 8 pins of both encoder and decoder ICs. To send a particular signal, address bits must be same at encoder and decoder ICs. By configuring the address bits properly, a single RF transmitter can also be used to control different RF receivers of same frequency.

On each transmission, 12 bits of data is transmitted consisting of 8 address bits and 4 data bits. The signal isreceived at receiver's end which is then fed into decoder IC.If address bits get matched, decoder converts it into parallel data and the corresponding data bits get lowered which could be then used to drive the LEDs. The outputs from this system can either be used in negative logic or NOT gates (like 74LS04) can be incorporated at data pins.

Flowchart of working is described as:

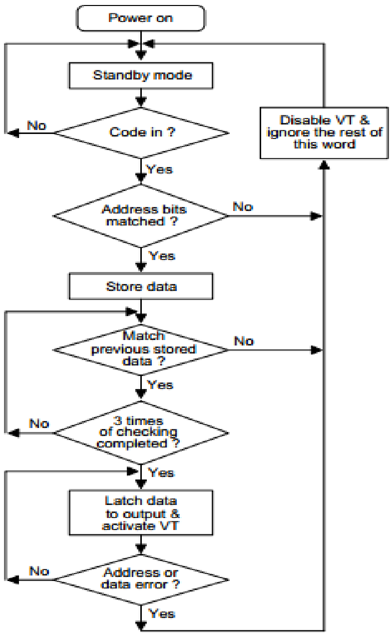

Figure 4. Flow Diagram Describing Working of HT12D Decoder

F. Receiver

The receiver section consists of a RF receiver working on same 433Mhz frequency, which wirelessly receives data from the transmitter at rate of 1kbps-10kbps.An ASK hybrid receiver module is used, with a typical sensitivity of -105dBm and a supply current of 3.5mA.

The coordinates on reception are the passed to a microcontroller through which they are sent to a PC using RS232 network.

G. Power Supply

To enable portability transmitter side has been powered up using a coin cell. A power budget was tabulated listing current consumptions of all the loads. Using these calculations battery capacity was decided and Li ion coin cell was chosen. Receiver side was powered using a USB cable.

IV. SOFTWARE PSEUDO CODE

A. Algorithm for Transmitter

1. Set the GPIO pins as analog input pins for X and Y outputs of the accelerometer respectively.
2. Initialize the ADC registers.
3. Select first analog channel.
4. Wait for the acquisition time of the X signal
5. Start analog to digital conversion.
6. Wait for the conversion to complete.
7. Output pattern detector code on a GPIO line.
8. Output the digital data bit by bit on the GPIO
9. Select second analog channel
10. Wait for the acquisition time of the Y signal
11. Start analog to digital conversion.
12. Wait for the conversion to complete.
13. Output the digital data bit by bit on a GPIO
14. Read the pin where switch is configured.
15. Transmit zero if switch is pressed else transmit one.
16. Repeat from step3.

B. Receiver Code

1. Set analog pin as general purpose I/O pin.
2. Initialize TXSTA and RCSTA for asynchronous mode.
3. Set baud rate= 2400 and a pin as input.
4. Enable transmission to PC.
5. Set a delay and read the input bit
6. Wait for the pattern to get detected
7. When pattern matches, copy the data byte to TXREG.
8. Wait for the transmission to complete.
9. Repeat from step 5.

C. Matlab Code

1. Import java.awt.Robot class into MATLAB.
2. Create an object mouse of this type.
3. Connect serial port object s to the device using fopen.
4. Set baud rate=2400.
5. X= Read data from controller available on s.
6. Y= Read data from controller available on s.
7. Click = Read data from controller available on s.
8. if x < 75, move the cursor left
9. else if x>90, move the cursor right
10. if y < 75, move the cursor down
11. else if y>90, move the cursor up
12. If click==0, click the mouse.
13. Repeat from step 5.

V. TESTING AND RESULTS

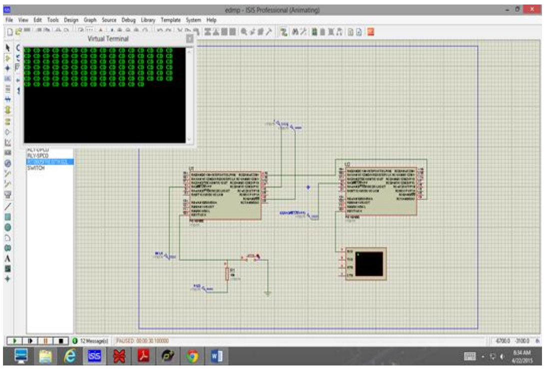

Figure 5. Proteus Simulation

Before practical implementation of the circuit, it was initially simulated in Proteus. Entire code was verified and working of the circuits was checked by giving pseudo inputs to the system.

Prior to integration of different modules, all were tested individually by emulating expected inputs. Accelerometer was tested in a angle rotating setup. This setup allows it to keep the accelerometer at a fixed angle with ground level. Voltages at different angles were tabulated and linearity was observed. Analog to digital converter was tested by giving different voltage inputs and the results were tabulated and error was computed. Transmitter was checked for its transmission power and receiver for its sensitivity along with its interface with encoder and decoder. In integrated testing, the coordinates sensed by the accelerometer were given as input to the three analog channels of PIC16F690 controller. The data was process and a delay was introduced and it was sent bits by bits from the microcontroller to the RF module TX.

The voltage on the data pin of TX module was varying along with the change in input coordinates on the accelerometer. This data was wirelessly transmitted over from the TX module to the RX module and then it was processed on the RX side using PIC16F690 and then was serially transmitted over the serial to USB converter to the PC.

The serially transmitted data was observed on TERMITE SOFTWARE on the Prolific COM port on the PC. The TTL topology controller was interfaced with PC which is CMOS compatible. The data was also serially scanned on MATLAB. The voltages received by receiver side were converted in coordinates by MATLAB code and the cursor changed its position.Java.robot file was externally attached to make the movement possible.

Accelerometer Tests:

1. Bias stability
2. Scale factor or sensitivity of an accelerometer is the ratio of the sensor electrical output to mechanical input typically rated in mV /g.
3. Cross axis sensitivity
4. Zero and full scale output tests
5. Bandwidth test.
6. Bandwidth test
7. Hysteresis Test
8. Temperature drift

RF Modules (TX + Rx Pair) Tests:

1. Compatible with the Encoder HT12E and decoder HT12D Link.
2. Pattern Detector
3. Antenna Response to a given Frequency within

(396-433) MHz

IV. CONCLUSIONS

A new and innovative technique has been proposed and its design and implementation has been done to enhance the ease of communication between a machine and humans adding to the adaptability of the system. The goal of this project is to develop a system which recognizes the hand gestures using an accelerometer rather than using the conventional image processing. These gestures control the cursor on the screen of the computer. Mouse movements, clicking and smart functions are incorporated in the project. The challenge of replacing mouse was completed with some delay limitations which will be addressed in next prototype. The technique is not just limited to mouse movements but can be implemented for various other systems like wireless signature recognition or wireless robot control etc. making them more interactive and user friendly.

V. ACKNOWLEDGMENT

The authors wish to sincerely thank Dr. Anil D. Sahasrabudhe, former Director of College of Engineering, Pune, Dr. B. B. Ahuja, Hon. Director of College of Engineering, Pune, Dr. A. N. Sapkal,former head of the department (HOD), Dr. PritiRege, HOD, Electronics and Telecommunicaiton and Mr. Vinay Narayane for their valuable guidance, constant encouragement and kind help at various stages for the execution of this work. They also extend their gratitude towards the Department of Electronics and Telecommunication Engineering for providing them with lab testing facilities

REFERENCES

[1] M.Jain, Aditi, A.Lohiya, M.F.Khan, A.Maurya, "Wireless Gesture Control Robot: an Analysis",International Journal of Advanced Research in Computer and Communication Engineering Vol. 1, Issue 10, December, 2012.

[2] http://www.analog.com/library/analogdialogue/archives/43-07/fall_detector.html

[3] A. Nayyar, H. Lenka, "Design and Development Of Wrist-Tiltbased Pc Cursor Control Using Accelerometer",International Journal of Computer Science, Engineering and Applications 08/2013; 3(4):67-74. DOI: 10.5121/ijcsea.2013.3407

[4] A.S.Ponraj, E.N.Daniel"AWireless Gesture Controlled Human Computer Interface",International Journal of Engineering Technology and Computer Applications Vol.2, No.1, Apr 2012