Accelerometer-Based Surface Less Control Interface in Electronics

Vaibhav Chithore[1], Vaishnavi Gaikwad[2], Mahima Chaudhari[3]

[1,2,3]Dept. of E & TC Engg., Smt. Kashibai Navale College of Engineering, Savitribai Phule Pune University, Pune

[1]vaibhavchits@gmail.com
[2]vaishnavigaikwad05@gmail.com
[3]schaudharimr1998@gmail.com

Abstract

As computation is getting to play an important role in enhancing the quality of life, more and more research has been directed towards natural human-computer interaction. In a smart environment, people usually hope to use the most natural and convenient ways to express their intentions and interact with the System. Most of previous work on gesture recognition has been based on computer vision techniques. However, the performance of such vision-based approaches depends strongly on the lighting condition and camera facing angles, which greatly restricts its applications in the smart environments. With “S.L.I.C.E” we aim to overcome these restrictions. S.L.I.C.E proposes an accelerometer-based surface less control interface for computer systems. As a pre-process procedure, raw data output from accelerometer is recorded, processed in the Processor and transmitted to the Computer System wirelessly. For this purpose, a Bluetooth device is used which will transmit the processed data. Based upon this gesture is treated as a method of human-computer interaction and it is used to control computer systems. Further Gesture-Semantic Map is established, standard gestures are trained which finally results in recognition. The system will be able to recognize input gestures with increased speed and reliable recognition rate. This will enable the user to perform most of the typical interaction tasks in virtual environment by this accelerometer-based device without any contact with surface or the system.

***Keywords**—Gesture, accelerometer, gyrometer, wireless technology, motion sensor.*

I. INTRODUCTION

A Gesture recognition is a type of perceptual computing user interface that allows computers to capture and interpret human gestures as commands. The general definition of gesture recognition is the ability of a computer to understand gestures and execute commands based on those gestures. Most consumers are familiar with the concept through Wii Fit, X-box and PlayStation games such as “Just Dance” and “Kinect Sports.”

In order to understand how gesture recognition works, it is important to understand how the word “gesture” is defined. In it’s most general sense, the word gesture can refer to any non-verbal communication that is intended to communicate a specific message. In the world of gesture recognition, a gesture is defined as any physical movement, large or small, that can be interpreted by a motion sensor. It may include anything from the pointing of a finger to a roundhouse kick or a nod of the head to a pinch or wave of the hand. Gestures can be broad and sweeping or small and contained. In some cases, the definition of “gesture” may also includes voice or verbal commands with “S.L.I.C.E” we aim to overcome these restrictions.

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II. LITERATURE SURVEY

This paper presents three different gesture recognition models which are capable of recognizing seven hand gestures, i.e., *up*, *down*, *left*, *right*, *tick*, *circle*, and *cross*, based on the input signals from MEMS 3-axes accelerometers. The accelerations of a hand in motion in three perpendicular directions are detected by three accelerometers respectively and transmitted to a PC via Bluetooth wireless protocol. An automatic gesture segmentation algorithm is developed to identify individual gestures in a sequence. To compress data and to minimize the influence of variations resulted from gestures made by different users, a basic feature based on sign sequence of gesture acceleration is extracted. This method reduces hundreds of data values of a single gesture to a gesture code of 8 numbers. Finally, the gesture is recognized by comparing the gesture code with the stored templates. [1].

Different types of gestures their properties, how to detect them, procedures all these details are explained in brief.Gesture recognition refers to the process of understanding and classifying meaningful movements of the hands, arms, face, or sometimes head, however hand gestures are the most expressive, natural, intuitive and thus, most frequently used Gesture recognition has become one of the hottest fields of research for its great significance in designing artificially intelligent human-computer interfaces for various applications which range from sign language through medical rehabilitation to virtual reality.[2]

Jianfeng Liu1 et. Al. in their paper [3], propose an accelerometer-based gesture recognition algorithm. As a pre-process procedure, raw data output by accelerometer should be quantized, and then use discrete Hidden Markov Model to train and recognize them. Based upon this recognition algorithm, we treat gesture as a method of human-computer interaction and use it in 3D interaction subsystem in VR system named VDOM.[3]

Tuton Mallick [4] explained a system where most of the robotic arm is controlled by using accelerometer sensor with an artificial intelligent algorithm. This paper is proposed a gesture recognition based 6DOF robotic arm controller using gyro-meter with accelerometer to improve the stability and to detect the rotational gesture of human arm. The arm also has the capability to grab object. To find out the angular position of an object, it is easiest way to fuse 3axis accelerometer and 3axis gyro-meter sensor. A low cost MEMs chip (integrated 3-axis accelerometer and 3-axis gyro-meter) used to detect human arm gesture as well as its angular position. Here gyro gives gesture orientation data to determine dynamic gesture behavior. An artificial algorithm used to evaluate all gesture data which helps to train the robotic arm. The most popular Kalman filter used to find out the exact position of human arm more accurately. The communication between human hand and robotic arm interaction has been established wirelessly over *IEEE* standard Zigbee protocol interface. The result is that the arm's movement is synchronous with human arm gesture i.e. like a shadow mode. The artificial arm response time is very fast with human arm gesture. The control strategy is easier than other systems like joystick control and his system applicable for industrial purposes. This robotic arm has been developed in Arduino IDE platform and it is also applicable in different platform like embedded, intelligent peripheral and so on. In conclusion, some tests has been performed with this robotic arm and the results are discussed.[4]

A control system and method are provided for controlling a device The control system includes a control mechanism including a plurality of accelerometers and a processor for generating at least one control signal. The plurality of accelerometers provide acceleration measurements to the processor, the measurements describing the current acceleration of control mechanism in all directions. The processor receives the acceleration measurements and compares the acceleration measurements to a value range stored to determine if the movement of the control mechanism can be mapped to a pre-programmed motion stored during setup of the system, indicative of a control function. The processor generates at least one control signal in response to the detection of a pre-programmed motion. The control signal provides for control of a device. [5]

Handicap Wheel chairs are used by the people those who cannot walk due to physiological or physical illness, injury or any disability. Recently development has wide scope in developing smart wheelchairs. This proposed system a hand gesture controlled wheel chair is special kind of wheel chair which works with your hand gesture there are possibility to control the movement of wheel chair at desired direction just with your hand gesture .This system is divided into two main units. Memes Sensor transmitter and wheelchair control receiver. The Memes sensor, The ADXL335 is small thin, low power consumption, complete 3-axis accelerometer with signal conditioned voltage outputs. Which is connected to hand, is a 3-axis accelerometer with digital output (I2C) that provides hand gesture detection, you just need to wear a small transmitting device in your hand which include an acceleration meter this will transmit an appropriate command of 6- bit digital values and gives it to the PIC controller using ZigBee RF Module is a Trans-receiver module which provides easy to use RF communication at 2.4 GHz. It can be used to transmit and receive data at 9600 baud rates from any standard CMOS/TTL source. [6]

III. BLOCK DIAGRAM

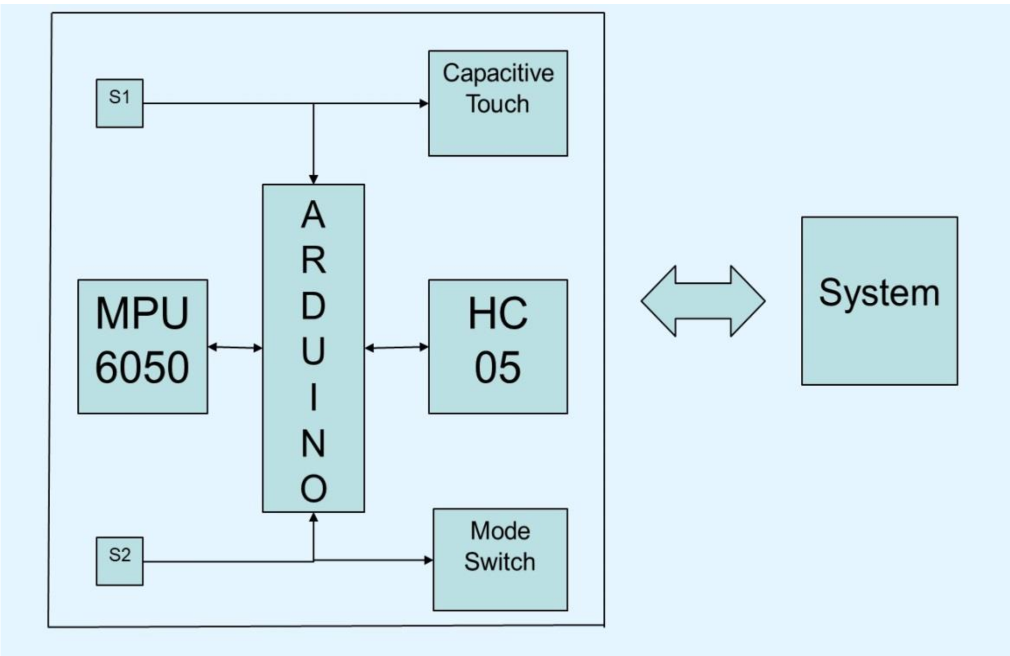

Figure 1. Block Diagram of System

The MPU-60X0 is integrated 6-axis Motion Tracking device that combines a 3-axis gyroscope, 3-axis accelerometer, and a Digital Motion Processor™ (DMP) all in a small 4x4x0.9mm package. With its dedicated I2C sensor bus, it directly accepts inputs from an external 3-axis compass to provide a complete 9-axis Motion Fusion™ output. The MPU-60X0 Motion Tracking device, with its 6-axis integration, on-board Motion Fusion™, and run-time calibration firmware, enables manufacturers to eliminate the costly and complex selection, qualification, and system level integration of discrete devices, guaranteeing optimal motion performance for consumers. The MPU-60X0 is also designed to interface with multiple non inertial digital sensors, such as pressure sensors, on its auxiliary I 2C port. The MPU-60X0 is footprint compatible with the MPU-30X0 family. The MPU-60X0 features three 16-bit analog-to-digital converters (ADCs) for digitizing the gyroscope outputs and three 16-bit ADCs for digitizing the accelerometer outputs. For precision tracking of both fast and slow motions, the parts feature a user-programmable gyroscope full-scale range of ±250, ±500, ±1000, and ±2000°/sec and a user-programmable accelerometer full-scale range of ±2g, ±4g, ±8g, and ±16g. An on-chip 1024 Byte FIFO buffer helps lower system power consumption by allowing the system processor to read the sensor data in bursts and then enter a low-power mode as the MPU collects more data. With all the necessary on-chip processing and sensor components required to support many motion-based use cases, the MPU-60X0 uniquely enables low-power Motion Interface applications in portable applications with reduced processing requirements for the system processor. By providing an integrated Motion Fusion output, the DMP in the MPU-60X0 offloads the intensive Motion Processing computation requirements from the system processor, minimizing the need for frequent polling of the motion sensor output. Communication with all registers of the device is performed using either I2C at 400kHz or SPI at 1MHz (MPU-6000 only). For applications requiring faster communications, the sensor and interrupt registers may be read using SPI at 20MHz (MPU-6000 only).

Arduino Nano is a surface mount breadboard embedded version with integrated USB. It is a smallest, complete, and breadboard friendly. It has everything that Diecimila /Duemilanove has (electrically) with more analog input pins and onboard +5V AREF jumper. Physically, it is missing power jack. The Nano is automatically sense and switch to the higher potential source of power, there is no need for the power select jumper. Nano’s got the breadboard-ability of the Arduino and the Mini+USB with smaller footprint than either, so users have more breadboard space. It’s got a pin layout that works well with the Mini or the Basic Stamp (TX, RX, ATN, GND on one top, power and ground on the other). This new version 3.0 comes with ATMEGA328 which offer more programming and data memory space. It is two layers. That make it easier to hack and more affordable.

The ATmega328P is a low-power CMOS 8-bit microcontroller based on theAVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, theATmega328P achieves throughputs approaching 1 MIPS per MHz allowingthe system designer to optimize power consumption versus processing speed.

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluetooth 04-External single chip Bluetooth system with CMOS technology and with AFH(Adaptive Frequency Hopping Feature). It has the footprint as small as 12.7mmx27mm. Hope it will simplify your overall design/development cycle.

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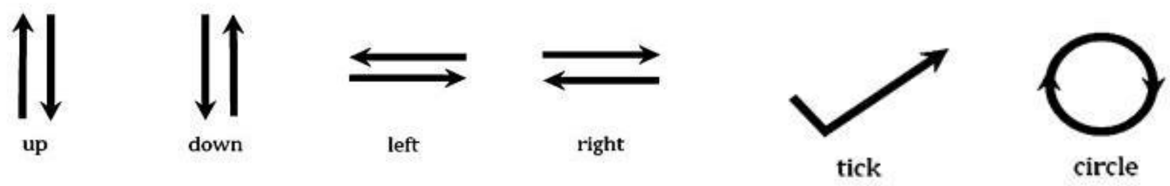
The Digital Sensor TTP223B Module Capacitive Touch Switch is based on a touch-sensing IC (TTP223B) capacitive touch switch module. Allows you to remove the worry of conventional push-type key Digital Capacitive Touch Switch Module is based on TTP223B. Normally, it outputs low and keeps at low power state. When a touch is sensed on the circular marked region, it outputs high and switches to the quick response state. When not being touched for 12 seconds, it switches to low power state again If the module is mounted in the surfaces of non-metallic materials such as plastic, glass, acrylic, you can make the keys hidden in the walls and desks.In addition to the thin paper (non-metallic) covering the surface of the module, as long as the correct location of the touch, you can make hidden in the walls, desktops and other parts of buttons.

The Arduino Nano can be powered via the mini-B USB connection, 6-20V unregulated external power supply (pin 30), or 5V regulated external power supply (pin 27). The power source is automatically selected to the highest voltage source.

IV. METHODOLOGY

The processed digital data is taken from accelerometer (MPU6050) and processed for transmission. Inputs from switches and capacitive touch is taken for further controllability purpose. The data is transmitted to the system using a Bluetooth module (HC05). The further processing is done and the actions are displayed on a preprocessed screen.

Motion calibration is used to measure the gesture(hand movement) accurately while calibrating the motion screen resolution is also taken into consideration. The device has 2 modes mouse mode and presentation mode. The gestures of *up, down, left, right* are displayed in the presentation mode while in mouse mode left & right click will be enabled as well drawing of different size and shapes is also possible through mouse mode. This could further lead to alphabet recognition.



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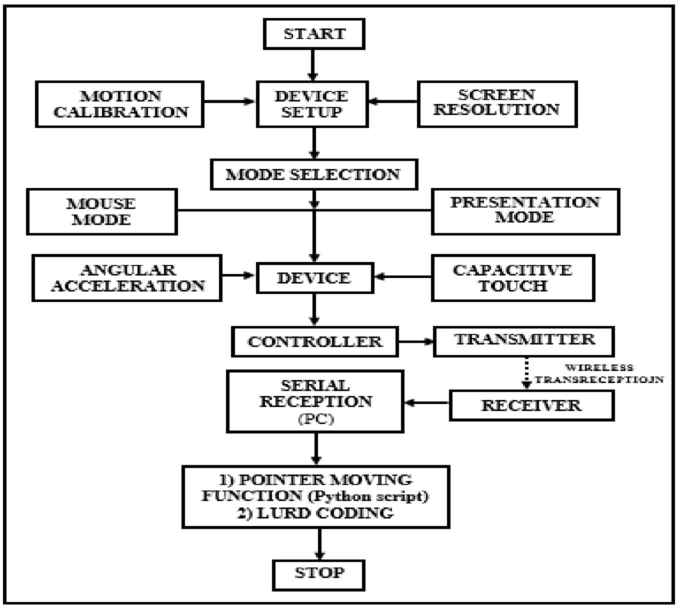

Figure 2. Methodology flow

A. GESTURE MOTION ANALYSIS

Gesture motions are in the vertical plane (as defined by the x-z plane in Fig 3a) or the projection of the motions is mainly can be decomposed into several acceleration and deceleration periods. As shown in Fig. 3b, an *up* gesture is actual consist of motion from point 1 to point 2, and then back to point 1. The velocity at the starting point 1, midpoint 2 and end point 1 are all zeros. For the convenience of analysis, point 3 is the point between point 1 and point 2 where acceleration changes sign and point 4 is the point between point 2 and point 1 where acceleration changes sign. Then the acceleration changes can be described as:

1- 3: acceleration on z-axis is negative (since positive z direction is downward); velocity changes from zero to a maximum value at 3; acceleration at point 3 is zero.

3 -4: acceleration on z-axis is positive; velocity changes from negative to positive and is maximum at point 4, where acceleration becomes zero.

4 -1: acceleration on z-axis is negative; velocity changes from positive to zero. Also, acceleration and velocity become zero at point 1.

The analysis below is illustrated by Fig. 3c is the real acceleration plot for the gesture *up* in which the dotted line

is the acceleration on z-axis and solid line is the acceleration on x-axis. We note that noise exists from sensor measured data. However, the noise does not influence the trend of the acceleration curves, and hence, the analysis of gestures based on the above method still works without adding computational burdens on a CPU by using a noise-filtering algorithm. Comparing the predicted acceleration pattern in Fig. 3c with the real acceleration plot , it is concluded that the trend of the real acceleration is the same with the prediction. After analyzing the other gestures, it was found that they all have unique acceleration patterns for classification. Gesture *down* is similar to *up* but with changes in directions, *left* and *right* and also similar, but the changes in motion axes information. *Tick*, *circle* are more complex since they have accelerations on both x- and z- axes simultaneously, but the accelerations on the two axes can be separated and decomposed, then the motion trend becomes similar to the above example. The uniqueness of each gesture trend makes the recognition algorithm possible, and the algorithms presented in this paper are based on this basic motion feature of the seven gestures.

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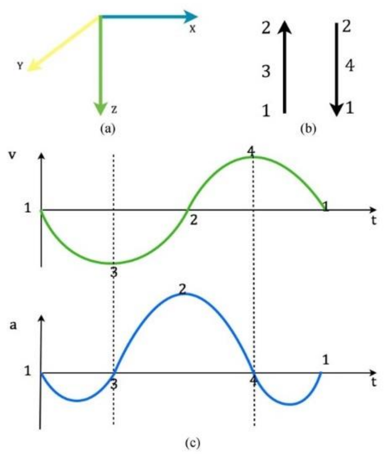

Figure 3. Gesture Motion Analysis

V. SENSING SYSTEM OVERVIEW

A. Sensor Description

The sensing system utilized in our experiments for hand motion data collection is shown in Fig. 4 and is essentially3-axesacceleration sensing chip integrated with data management and Bluetooth wireless data chips. The algorithms describedin this paper were implemented and run on a PC.

B. System Work Flow

When the sensing system is switched on, the accelerations in three perpendicular directions are detected by the MEMS sensors and transmitted to a PC via Bluetooth protocol. The gesture motion data then go through a *segmentation program* which automatically identifies the start and end of each gesture so that only the data between these terminal points will be processed to
extract feature. Subsequently, the processed data are recognized by a *comparison program* to determine the presented gestures

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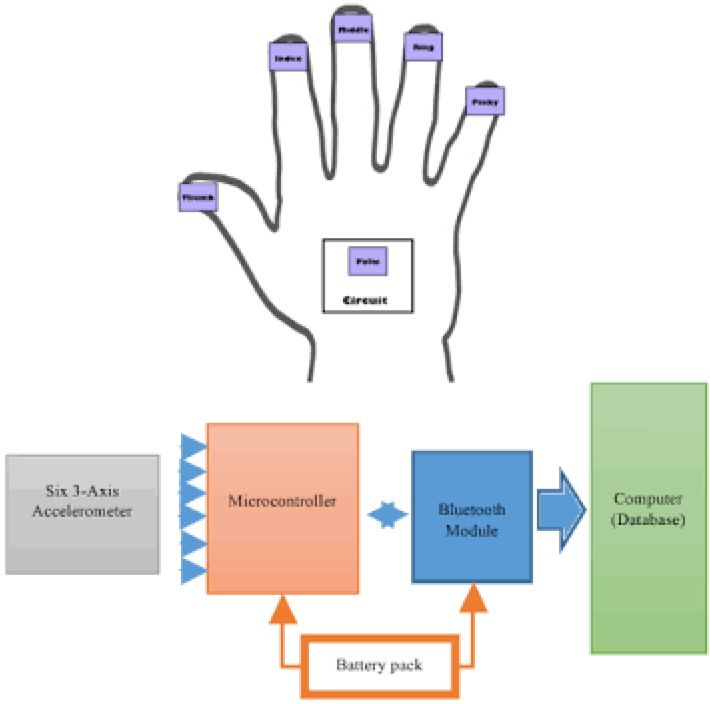

Figure 4. Sensing System representation

VI. CONCLUSION

The expected system will be able to recognize input gestures quickly with a reliable recognition rate. The users will be able to perform most of the typical interaction tasks in virtual environment by this accelerometer-based device without any contact with surface or the system. The expected accuracy and detection rate will be phenomenal.

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