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Mems Sensor Based Approach for Gesture Recognition to Control Media in Computer

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Abstract*: Gesture Recognition is the method of identifying and understanding meaningful movements of the arms, hands, face, or sometimes head. It is one of the most important aspects in the field of Human-Computer interface. There has been a continuous research in this field because of its ability for application in user interfaces. Gesture Recognition is one of the important areas of research for engineers and scientists. Nowadays the industry is working on the different implementation for the trouble free, natural and easy product which can be easy to handle. This paper proposed a method to work with motion sensors and interpret the motion of hand into various applications in a virtual interface. The Micro-Electro-Mechanical Systems (MEMS) accelerometers are used to capture the dynamic hand gesture. These sensors information is transferred to the microcontroller from where these data are transferred wirelessly to the computer system for actual processing of the data with the use of various algorithms.

Keywords*: Gesture Recognition, MEMS, Teensy, Accelerometer.

I. INTRODUCTION

Gesture recognition Technique is one of the important tools in the field of Human-computer interaction (HCI). As the Technology Advances in time, Researchers devoted to this, are struggling to develop the new way to find an intelligent, easy and more natural way for human-computer interaction. There are several techniques introduced in human-computer interaction such as face detection, speech recognition and motion gesture. Hand gesture provides an intuitive and more natural form of communication for humans. Gesture recognition system interprets human gestures into some commands, which can be used to control useful devices.

There are two main techniques in gesture recognition.

A. *Glove based Approach*

A Glove-Based Gesture Recognition system consists of sensors mounted on the glove for motion capturing, microcontroller for information processing and power supply. The wearable glove senses the orientation of user's hand along with the motion. The users are required to carry additional equipment which may feel inconvenient and disturbing, troubling the actual interaction. Because of which they are unfit for spontaneous interaction due to the complicated arrangement.

B. *Vision-based Approach*

Vision-based techniques use visual inputs like the camera to capture the gesture or expression to be used in the gesture recognition system. Vision-based techniques can deal with the problems of Glove-based techniques, but it has some of its own problems. Portability is a problem for most vision-based systems that require still arrangements of the video cameras. Video processing of information has several problems as they are highly dependent on light conditions, video camera settings and an environment.

In our Proposed system we are following the Glove based gesture recognition approach because it has high accuracy and fast reaction speed. To minimize the wearable part of the system we used the Teensy USB microcontroller development board. It is a small sized chip with onboard microcontroller and Analog to digital converter and uses very low power (3.3v – 5v), which is perfectly suitable for our system. Also, we are using 6 MEMS accelerometer for a complete orientation data of hand and one flex sensor for any clicking operation. Zigbee transceiver is used to make the system wireless. The receiver module is attached to the computer where the sensor data further processed with the use of various algorithms and performs related tasks.

II. LITERATURE SURVEY

This section describes some of the related works already done in the field of Gesture recognition.Yikai Fang, Kongqiao Wang, Jian Cheng and HanqingLu [1], proposed a real-time hand gesture recognition system. In this system, a particular gesture is required to trigger the hand detection which is followed by tracking. Then hand is segmented using motion and color cues and applied the proposed method to the navigation of image browsing. It locates hands without separate segmentation mechanism and the classifier is learned from a small set of image samples, so the generalization is very limited.

S. Zhou, Z. Dong, W. J. Li, and C. P. Kwong [2], proposed a system in which a Micro Inertial Measurement Unit (MIMU) is based on Micro Electro Mechanical Systems (MEMS) sensors is applied to capture the motion information produced by alphabets written by the human user in air. The MIMU is built to capture the three-dimensional accelerations and angular velocities of the motions during writing by hand. In this paper, they used SOM as a character recognition method for training and classifying data transformed by DCT. However, SOM has some limitations which affect its classification results, such as its sensitivity to data input sequence and signal level.

SiddharthSwarup Rautaray and Anupam Agrawal [3], proposed a computer vision-based gesture recognition techniques and developed a vision-based low inexpensive device to control the VLC player by hand gestures. VLC media player consists of a computational module which is used to analyze the Principal Component for hand gesture information and finds the feature vectors of the gesture and saved it in the memory. The identification of the gesture is done by K-Nearest Neighbour algorithm. This application is less robust in recognition phase. Robustness of the application can be increased by applying some more robust algorithms to reduce noise and blur motion. For controlling VLC, the application uses global keyboard shortcut in VLC and making keyboard event of that global shortcut with keybd_event () function. It's not the smart way of controlling any application.

Ruize Xu, Shengli Zhou and Wen J. Li [4], proposed 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 gesture information provided by MEMS triaxial accelerometers. The accelerations of a hand in motion in three perpendicular planes are detected by three accelerometers respectively and transmitted to a PC by using Bluetooth transceiver. An automatic gesture segmentation algorithm is developed for identifying the individual gestures in a sequence. The segmentation algorithm used in this paper has some limitations such as inaccurate results in finding the terminal points of gestures. Hence the accuracy of the system is limited.

Chetana S. Ingulkar and A. N. Gaikwad [5], proposed a real-time Human-Computer Interaction (HCI) based on the hand data glove and K-NN classifier for gesture recognition is proposed. The gestures classified are categorized as clicking, rotating, dragging, pointing and ideal position. There are two types of sensors are used flex sensor and accelerometer, which are completely different with each other hence makes system complex to calculate & recognize a perfect gesture.

Meenaakumari.M. and M.Muthulakshmi [6], proposed a portable gesture recognition system that has been developed with the use of trajectory recognition algorithm. The portable device consists of a 3-axes accelerometer, a microcontroller, and a Zigbee wireless transceiver module. Users can use this portable system to write digits and make hand gestures at normal speed. The limitation of the proposed trajectory recognition algorithm is that it can only identify a letter or a number drawn with a single stroke.

R. Suriya and V. Vijayachamundeshwari [7], discussed work done in the area of hand gesture recognition using various methods like Hidden Markov Model, simple mouse control and MEMS accelerometer. They have described hand detection methods in the pre-processed image for detecting the hand image, which is the main process in gesture recognition.

O. Sidek and M. A. Hadi [8], proposed the development of wireless Bluetooth hand gesture recognition system using six 3-axis accelerometers embedded in a glove with a database in a computer for samples. This system can identify any sampled data saved in the database while making the device portable and mobile to the user by using wireless Bluetooth technology. The system analyzed gesture data such as static data, dynamic data, and average recognition rates relationships are discussed in this paper. In this paper, the system only recognizes the gestures on the basis of the existing set of gestures in the database but it is not dedicated for a particular application.

III. PROPOSED WORK

This paper proposed the technique for development of wireless hand gesture recognition system using six 3-axis accelerometers and a flex sensor embedded in a glove and a media player application in the computer which can be controlled by making gesture using the glove. This system can recognize any sampled data saved in the database while promoting maximum portability and mobility to the user via wireless technology.

The system has six 3-axis accelerometers – one on each finger and one on the back of the palm integrated into the glove to detect hand positions and motions. Also, one flex sensor is used to provide any clicking operation for the media player. All the accelerometers are connected to a microcontroller and the raw data received are mapped and arranged in an array before it is transferred serially to a wireless module. Data acquired by the computer by the wireless module are saved in a database called gesture library by means of a graphical user interface (GUI) in a computer. The GUI system is created to ease the collection of sample data and it can also be used to recognize gestures from the glove. The recognition system will return the recognized gesture based on the highest probabilities score. According to the detected gesture pattern by the recognition system, the appropriate commands are given to the media player to control the various functions of it.

The components selected for the proposed system are as follows.

A. Accelerometer Fig 1 ADXL335 Accelerometer

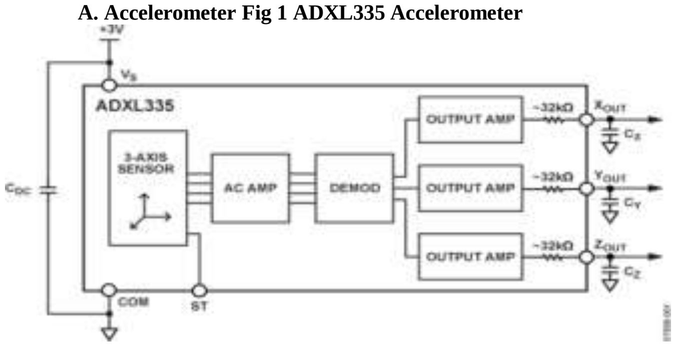

Fig 2 **ADXL335 Circuit diagram**

Accelerometers are the sensors which sense acceleration. For achieving analog input values we select the ADXL335 analog 3-axes accelerometer. The ADXL335 is a small, thin, low power, 3-axis accelerometer with signal based voltage outputs. The sensor measures acceleration with a range of ±3 g. The sensor can be used to measure static acceleration in tilt-sensing applications, and dynamic acceleration arises from motion, shock, or vibration. It uses extremely low power (only 320uA) which is perfectly suitable for our battery based application.

It is a 3-axis accelerometer means it can sense the acceleration in three dimensions X, Y, and Z at the same time, provides better judgment towards detection of hand movement.

The user can select the bandwidth of the accelerometer using the CX, CY, and CZ capacitors at the X, Y, and Z pins. Bandwidths can be selected to according to the application, with a range of 0.5 Hz to 1600 Hz for X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis.

A. *Teensy*

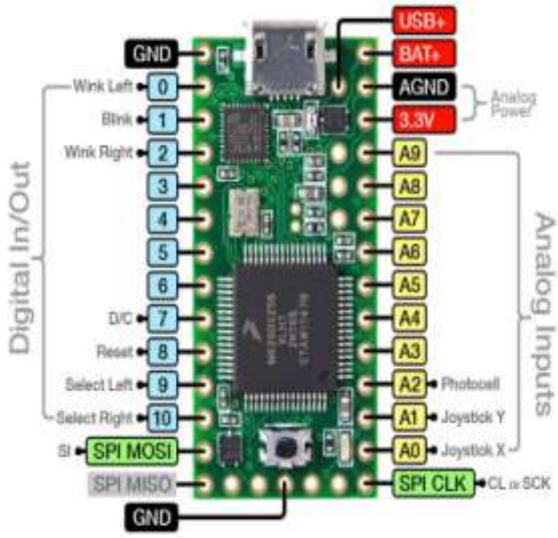

Fig 3 Teensy 3.2 Pin diagram

The Teensy board is a complete USB-based microcontroller development system in a very small size, capable of implementing many types of projects. It consists of 32 bit ARM cortex M4 core which is based on ARM 7 architecture. It also had on chip 16 bit analog to digital converter (ADC) and works on 3.3 to 5 volts.

Teensy comes pre-flashed with a boot loader called Teensy loader, so it can be programmed using the onboard USB connection, No external programmer needed. We can program for the Teensy in your favourite program editor using C or you can install the Teensyduino, an add-on for the Arduino IDE and write Arduino sketches for Teensy.

The main features of Teensy which make it suitable for our system are,

1) *Dimensions:* its dimensions are 1.4 x 0.7" (~35 x 18 mm), it is so small that can be easily mounted on the glove and handled easily.

2) *Power:* It works on 3.3v to 5v only, hence suitable for a battery based system. Also, It has an on-chip voltage regulator which can provide a regulated voltage of 3.3 volts and up to 100mA, which is sufficient to power all the sensors and wireless module of our system.
3) *Microcontroller:* It has 32-bit ARM Cortex M4 core based on ARM 7 architecture, which is efficient and dependable.
4) *ADC:* It has on-chip two 16 bit analog to digital converters (ADC), which is required in our system to convert analog sensor values to digital.
5) *Analog Inputs:* It has 21 Analog inputs of 16 bit each, which is the most important requirement of our system to connect 6 accelerometers of 3 input each and 1 flex sensor.
6) *Programming:* is easy to program using onboard USB provided using any c compiler or Teensyduino IDE based on Arduino.

B. *Flex Sensor*

Fig 4 A Flex Sensor

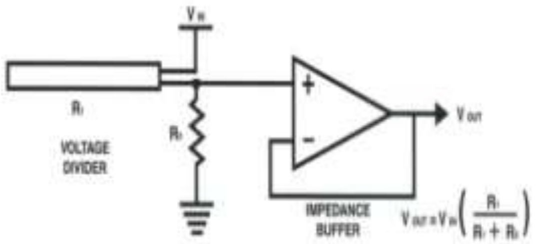

Fig 5 Basic Flex Sensor Circuit

Flex sensors are passive resistive devices that can be used to detect bending in one direction. They were popularized by being used in the Nintendo Power-Glove as a gaming interface. The change in resistance depends upon the amount of bending on the sensor. As the angle of bend increases the resistance increases. A flat un-flexed sensor has a resistance of 10 KΩ. As the flex sensor is bent, the resistance gradually changes. When flexed all the way the resistance rises to 20KΩ.

In our System, the flex sensor is connected to a 10KΩ resistor in series to form a voltage bridge. The voltage at the middle of the bridge is provided to the analog input of the Teensy to detect the changes in bending of the sensor by voltage values received and converts it into digital form using it's built in ADC.

C. *Wireless Module*

Fig 6 A nRF24L01+ wireless module

The nRF24L01+ is an ultra-low power wireless trans-receiver module, which operates in the 2.4 GHz band. The configuration of the module can be done by a Serial Peripheral Interface (SPI) where data is sent in both ways at once but on separate lines. NRF24L01+ has internal FIFOs which ensure smooth data flow with the use of 6 data pipe multilevel. The module has a built-in state machine which controls the transmission between its operating modes and the configuration registers are accessible in all operational modes. It uses GFSK modulation. A user can configure parameters like frequency channel, output power and transmission rate. NRF24L01+ supports the data transmission rate of 250 kbps, 1 Mbps and 2Mbps.

Two wireless modules are used in our system one acts as a transmitter, situated on the glove itself and second acts as a receiver, which is connected to the computer. The sensor data are transferred from the sensor glove to the computer by this wireless module.

D. *Computer*

A computer is required which collects the sensor data by the wireless receiver module attached to it. The actual processing of data is implemented here with the help of some algorithms consist of three main components quantizer, Model and Classifier. As an accelerometer continuously transfers a sequence of data, there is a need of quantizer to cluster or make groups of the gesture data. Here, a common k-mean algorithm can be used. The model part of processing has to be a hidden Markov model since it is mostly used in the gesture recognition and delivers reliable results for patterns. The remaining component is a classic Bayes-classifier. In addition to these main components, we can use two filters for pre-processing of the sensor data, an "idle state" and a "directorial equivalence" filter. Both are reliable to reduce and simplify the incoming sensor data.

CONCLUSIONS

This paper proposed a MEMS sensor-based gesture recognition system which is wireless and modular in nature. Since the hardware used are of small size and efficient, the system becomes easy to handle. The applicability of the proposed system is defined by controlling a media player application created for the purpose and user can control its functionality with the use of hand gestures. The system used different algorithms such as K-mean, Hidden Markov model and Bayes classifier to efficiently process the sensor information and to detect the gestures accurately to perform the assigned task to that particular gesture.

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