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MEMS Based Trajectory Recognition and Human Computer Interaction for the Disabled People

Saju A., Bredjet A., Paul A. J.

Abstract— The growth of miniaturization technologies in electronic circuits and components has greatly decreased the dimension and weight of consumer electronic products, such as smart phones and handheld computers, and thus made them more handy and convenient. Within the last decade, many improvements have been made in the performance of gesture and speech recognizers and current technology is discussed in relation to the needs of the disabled population. This paper presents an accelerometer-based device for gesture recognition and speech recognition system for the disabled people. The speech recognition system is attached to the device .By changing the position of MEMS (Micro Electro Mechanical Systems) users are able to show the characters' in the PC and the user speech commands can be interpreted by the computer. The acceleration signals measured from the accelerometer are transmitted to a computer via the wireless module.

Index Terms— Accelerometer, Trajectory recognition, Speech Recognition, MFCC, neural network, Gesture Recognition, MEMS

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1 Introduction

Due to the rapid development of computer technology, human–computer interaction techniques have become an indispensable component in our daily life. Recently, an attractive alternative, a portable device embedded with inertial sensors, has been proposed to sense the activities of human and to capture his/her motion trajectory information from accelerations for recognizing gestures or handwriting. A significant advantage of inertial sensors for general motion sensing is that they can be operated without any external reference and limitation in working conditions. However, motion trajectory recognition is relatively complicated because different users have different speeds and styles to generate various motion trajectories. In our system, users can use the device to write digits or make hand gestures, and the hand motions accelerations are measured by the accelerometer and the voice are wirelessly transmitted to a computer for online trajectory recognition and speech recognition.

2 Related work

Some studies have focused on the development of digital pens for trajectory recognition and HCI applications. For instance, an alternative method of conventional tablet-based handwriting recognition has been proposed by Milner [1]. In his system, two dual-axis accelerometers are mounted on the side of a pen to generate time-varying x- and y-axis acceleration for handwriting motion. The author employed an HMM with a band pass filtering and a down-sampling procedure for classification of seven handwritten words. The best recognition rate is 96.2% when the number of states of the HMM is equal to 60. Oh et al. [10] presented a wand like input device embedding a triaxial accelerometer and a triaxial gyroscope for online 3-D character gesture recognition. Fisher discriminant analysis was adopted, and different combinations of sensor signals were used to test the recognition performance of their device. When all six axes raw signals were used as inputs of the recognition system, the recognition rate was 93.23%.

In addition, they proposed an ensemble recognizer consisting of three sub recognizers with the following signals as inputs: acceleration, angular velocity, and estimated handwriting trajectory. The recognition rate of the recognizer was 95.04%. Similarly, a gesture recognition system consisting of a gesture input device, a trajectory estimation algorithm, and a recognition algorithm in 3-D space was proposed by Cho et al. [1]. We developed a portable device which consists of triaxial accelerometer, microcontroller and wireless transmission module. The acceleration signals measured from the Tri axial accelerometer is transmitted to a computer via the wireless module. Users can use this pen to write digits or make hand gestures. By varying the position of Mems we can display the characters' in PC .

Polysilicon springs suspend the MEMS structure above the substrate such that the body of the sensor can move in the X, Y and Z axes. Acceleration causes deflection of the proof mass from its centre position. Around the four sides of the square proof mass are sets of radial fingers.

The advancement in IC technology and MEMS fabrication processes have enabled commercial MEMS devices that integrate micro sensors, micro actuators and microelectronic ICs, to provide perception and control of the physical environment. The devices, also known as 'microsystems' are able to get information from the environment by measuring mechanical, thermal, biological phenomena. The IC then processes this information and directs the actuator(s) to respond by moving,

- *Saju A is currently working as Associate Professor in Musaliar College of Engineering, Pathanamthitta, Kerala , link2saju@gmail.com*
- *Bredjet A, Ph.D. Research Scholar, Karpagam University,Coimbatore, Tamilnadu, bredjet.em@gmail.com*
- *Dr. Paul A J is the Principal of Caarmel Engg college, Pathanamthitta, Kerala*

positioning, regulating, or filtering. Any device or system can be deemed a MEMS device if it incorporates some form of MEMS-manufactured component.

3 DEVELOPED SYSTEM

We designed a portable device which consists of triaxial accelerometer, microcontroller and wireless transmission module.

o The Acceleration signals measured from the Tri axial accelerometers are transmitted to a computer via the wireless module. Users can use this pen to write digits or make hand gestures.

o By varying the position of MEMS we can display the characters in PC and we can control with the help of MEMS Sensor.

o The voice recognition system interprets the voice commands from the user.

3.1 Hardware Used

- PIC 16f877a (Microcontroller)
- Zigbee Transceiver module
- Tri Axis Mems Accelerometer sensor

3.2 Software Used

Mplab IDE Compiler: This Compiler is used to convert your programming language (Embedded C) into Hex File.

o Embedded C:This is the language used in the microcontroller

o Pickit2 Programmer: This is used to burn the hex file into the microcontroller and Linear Prediction is their basis.

o Matlab: Software used for Signal Processing

4 VOICE RECOGNITION

Now a days the well known speech recognition systems use cepstrum parameters which are extracted. Although there are linear forecast models which are pure mathematics models, they ignore the characteristics of voice processing by human auditory system.

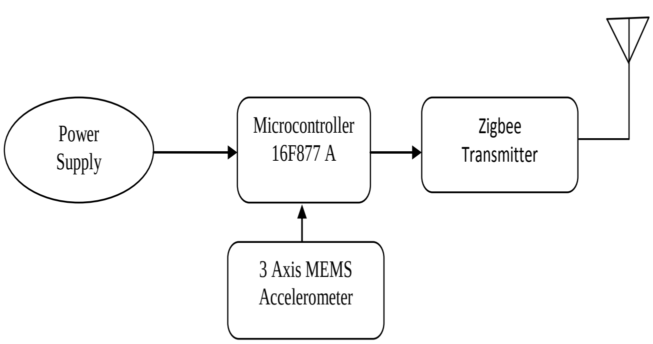

Fig. 1 : Transmitter Section

In speech recognition systems, taking into consideration the characteristics of the auditory system and with some preprocessing, the recognition rate of the whole system is improved. To distinguish between high and low the characteristic of sound used is the Tone.

Actually the human ear perception is not a linear direct ratio to the frequency of the voice signal, it is also related to the strength and the waveform of the sound. In more than certain frequency, the human ear perception of frequency shows logarithm nonlinear. By using Mel frequency scale values approximately correspond to the actual frequency distribution, and thus more similar characteristics of human ear. The approach used in voice recognition is shown in Fig 2.

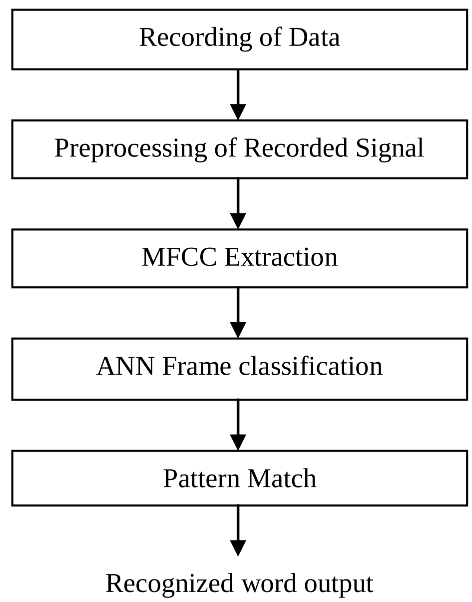

Fig 2: Speech Recognition System Architecture

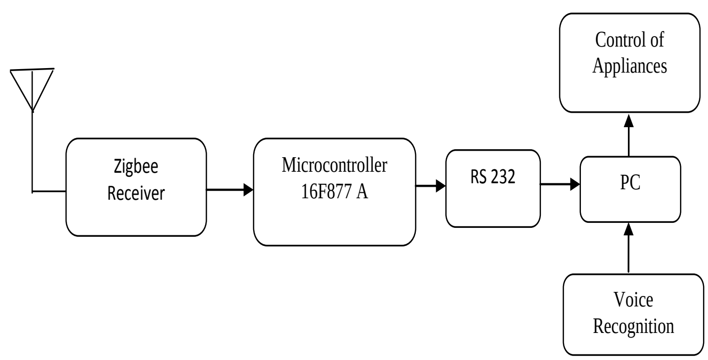

Fig. 3: Receiver / Recognition Section

4. Experimental test results

4.1 Gesture Recognition

We recruited ten males and 10 females (age: 20 ± 2 years old) to participate in this Experiment. Each participant was asked to hold this device to draw the trajectories of Arabic numerals. The acceleration signals after the signal preprocessing procedure of the proposed trajectory recognition algorithm for the digit 0. The calibrated acceleration signals acquired from the accelerometer module. Subsequently, the acceleration signals were filtered via the moving average filter to reduce the high-frequency noise. Finally, the gravitational acceleration was removed from the filtered acceleration signals via a high-pass filter to obtain the accelerations caused by hand movement.
With the preprocessed accelerations, features are generated by the feature generation procedure. The acceleration hex output is as shown in Table 1.

Table 1: Accelerometer Hex output

10000000830100308A0004282030840052301C20F4
:10001000A0308400AA301C2083010730DD00F630B8
:10002000DC00523084005C30202083010A128A11E7
:10003000DE2E04068001840A0406031D19280034FC
:10004000F0000A128A1130200A128A118000840AF4
:10005000040870060319003421288312O313DC00FE
:10006000DD1B3B285D1B43285D088A005C08DC0A1
:100070000319DD0A820083135D1883175C08DC0A0C
:10008000840000080800443465347634693463 34ED
:100090006534203463346F346E34743472346F34A6
:1000A0006C340034413463346334653 46C34653407
:1000B00072346F346D346534743465347234203482
:0200C00000340A

4.2 Speech Recognition

We implemented a Neural Network based Isolated speech recognition system consisting of four commands.
The database consists of 200 speech samples for each command.
Sampling rate: 16 kHz
Voice: 16 bit mono .wav file
Using MFCC as feature -Mel Frequency Cepstral Coefficients {39-dimensional vectors computed from 13 Mel Frequency Cepstrum Coefficients (MFCC) , 13 delta and 13 acceleration coefficients } and (Multilayer Perception) Neural Network for pattern recognition.
Confusion matrix was obtained as shown in Table 2 below where a, b, c, d stands for four commands.

Table 2. Confusion matrix

	a	B	c	d
a	4008	40	120	56
b	68	4100	48	72
c	124	84	4096	128
d	132	28	132	4084

5 Conclusion

This paper has presented a gesture and speech recognition framework that can construct effective classifiers for acceleration-based handwriting, gesture and voice recognition. The recognition algorithm consists of acquisition, preprocessing, generation, selection, and extraction of the feature. Experimental results show that the use of the features extracted from arm trajectories effectively works on the recognition of dynamic gestures of a human, and gives a good performance to classify various gesture patterns and voice signals. This encourages us to further investigate the possibility of using effective tools for HCI applications. One such device is an eye tracker, which allows an individual to control a computer cursor by moving his eyes. Another innovative device called CyberLink which consists of sensors built into a headband that detect and respond to electrical signals originating from muscles and the electrical activity in the brain may also be included in future for the severely disabled people.

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