MEMS Accelerometer Based Gesture Recognition For System Security and Remote User Notification

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***Abstract*— This project is based on the MEMS based accelerometer used for hand gesture recognition for security purposes. This aims to provide a security to any system consisting of confidential data. Thus in this project we will be using MEMS accelerometer which is the central component of this project. This will intake the gesture as an input from the user. The input will then be given to the Matlab program which has the security code in it. This program will be used to map the stored data/templates of the specified user in the system. If the template is matched then the access will be given to the person else not. For the templates to be stored there is a need of use of database MySQL which will store N number of templates in the database. Here if any suspicious or non specified person tries to access the system the person will not be allowed to access the system. Its log will be generated in the database where the details of the person and the event will be stored i.e. gesture of the person, number of times the gesture been made, time for which the person was on the system and so on. Also after 3-5 unsuccessful attempts for login the system will be locked and the intimation of the same will be given to the existing user through the GSM module as a SMS on its mobile phone. Thus the user is able to access the system or is informed by the system at remote places as well.**

Keywords—Handgesture; MEMS accelerometer; MySQL; Matlab.

1. INTRODUCTION

Now a days, the expansion of human machine interaction technologies in electronic circuits has been greatly reduced the dimension and weight of consumer electronics products such as smart phones and handheld computers, and therefore will increases our day to day convenience. Recently, an attractive alternative, a conveyable embedded device with inertial sensors, has been projected to sense the activities of human and to capture their motion trajectory information from accelerations for handwriting and recognizing gestures. The foremost necessary advantage of inertial sensors for general motion sensing is that they can be operated without any external reference and limitation in operating conditions. However, motion trajectory recognition is comparatively tough for different users since they have different speeds and styles to generate various motion trajectories. Thus, several researchers have tried to avoid the problem domain for increasing the accuracy of handwriting recognition systems. During this work a miniature MEMS accelerometer based recognition systems which acknowledge four hand gestures in 3-D is constructed by using this four gestures, numerical and alphabets will be recognized in the digital format [1] [3].

The increase in human-machine interactions in our daily lives has made user interface technology progressively more important. Physical gestures as intuitive expressions will greatly ease the interaction process and enable humans to more naturally command computers or machines. For example, in telerobotics, slave robots have been demonstrated to follow the master's hand motions remotely. Other proposed applications of recognizing hand gestures include character-recognition in 3-D space using inertial sensors, gesture recognition to control a television set remotely, enabling a hand as a 3-D mouse, and using hand gestures as a control mechanism in virtual reality. Moreover, gesture recognition has also been proposed to understand the actions of a musical conductor In our work, a miniature MEMS accelerometer based recognition system which can recognize seven hand gestures in 3-D space is built. The system has potential uses such as a remote controller for visual and audio equipment, or as a control mechanism to command machines and intelligent systems in offices and factories. can also be employed to provide input to a gesture recognizer. But sometimes, the technology employed for capturing gestures can be relatively expensive, such as a vision system or a data glove.

To strike a balance between accuracy of collected data and cost of devices, a Micro Inertial Measurement Unit is utilized in this project to detect the accelerations of hand motions in three dimensions [2]. There are mainly two existing types of gesture recognition methods, i.e., *vision-based* and *accelerometer and/or gyroscope* based. Due to the limitations such as unexpected ambient optical noise, slower dynamic response, and relatively large data collections/ processing of vision-based method, our recognition system is implemented based on an inertial measurement unit based on MEMS acceleration sensors. Since heavy computation burden will be brought if gyroscopes are used for inertial measurement, our current system is based on MEMS accelerometers only and gyroscopes are not implemented for motion sensing. Existing gesture recognition approaches include template- matching, dictionary lookup, statistical matching, linguistic matching , and neural network [6]. For sequential data such as measurement of time series and acoustic features at successive time frames used for speech recognition, HMM (Hidden Markov Model) is one of the most important models .It is effective for recognizing patterns with spatial and temporal variation. In this paper, we present three different gesture recognition models, which are: 1) sign sequence and Hopfield based gesture recognition model; 2) velocity increment based gesture recognition model; and 3) sign sequence and template matching based gesture recognition model out of which any one is used. In these three models, in order to find a simple and efficient solution to the hand gesture recognition problem based on MEMS accelerometers, the acceleration patterns are not mapped into velocity, displacement or transformed into frequency domain, but are directly segmented and recognized in time domain[1]. By extracting a simple feature based on sign sequence of acceleration, the recognition system achieves high accuracy and efficiency without the employment of HMM.

So in this project we are going to implement gesture recognition for security purposes, wherein the gesture pattern combinations will allow access to the concerned person. The novel feature of this project is that it can keep the track of N number of templates which is stored in the Database. For templates to be identified we are going to use three models simultaneously where in earlier cases only one was used. Furthermore the intimation of the system accessed by other person will be informed to the existing user using GSM module [10][11].

2. METHODOLOGY

This project starts of with the use of MEMS (Micro Electromechanical Systems) based accelerometer for the use of gesture recognition for security purposes. In this project MEMS accelerometer has been used for the gesture recognition due to its low cost and low power usage. This MEMS accelerometer is been used along with a microcontroller board which will provide the data from the MEMS to the microcontroller software. This software mainly KEIL is being linked with MATLAB or IPLAB software where the system program is written. The software also uses MySQL database for information storage from the MEMS. The data received from the MEMS might be of a authorized user or a non user. The gesture of any user with the system, its gesture will be mapped with the gesture of the database and appropriate decision will be taken [4]. Also if any non user with not the authorized gesture tries to access the system its gestures, the duration for which he has been with the system, time of approach to the systems, etc and so on will be recorded. Their logs will be generated in the database so that user may come to know the number of authorized and non authorized approaches made with the system. Also the system will be connected with the GSM module for wireless data transmission to the user. That means user is able to know when the access is made by anyone, is the access authorized one or not, also is the system properly working, has it been crashed and many such in formations will be sent to the user through the messages [1][2]. Also for increasing the security to a higher level the user and approach to a two level security i.e. firstly by gesture and then user will give access to the system by sending message to sytem which will give the access to the one approached. Thus the user is able to operate the system even at remote place and is also intimated with the same [6].

3. HARDWARE IMPLEMENTATION

In this paper we suggested three hardware's i.e. MEMS Accelerometer, microcontroller board and GSM module.

A. MEMS Accelerometer

MEMS Accelerometer is a device which is used for sensing the gestures from the user. MEMS Accelerometer is capable of sensing any type of gesture i.e. 1-D, 2-D, 3-D gestures effectively. Its main advantage is that it is very low cost, low power utilizing and long lasting device. It utilizes power of current in milli Amperes. Also the device is suggested to be long lasted for 10 years and above.

MEMS Accelerometer has another version of accelerometer known to be as Ultra Low Power MEMS Accelerometer which utilizes the current in nano Amperes. The device then forwards the sensed gestures to the feature extractor using microcontroller board.

B. Microcontroller board

The Microcontroller board senses the gesture patterns and provides it to the matlab software for template generation and template matching.

C. GSM Module

When the gestures are compared and then the decision is made whether the permission is to be granted or not. Thus its notification is given to the existing user using GSM module and from the user the message codes can be received so as to manage the system from the remote place also.

4. Software Implementation

A. Keil

It is a microcontroller software used for receiving the gesture patterns from the user. These gestures are not the processed ones and are to be fed to the Matlab software.

B. Matlab

Matlab is a signal processing software. We use this one for processing the gestures signals in the proper format. Here feature extraction is done and the generated template gesture is compared with the existing templates stored in the database. The matlab software could not store many gestures thus we use here Database using MySQL.

C. MySQL.

MySQL is database software. It is used for storing templates and generating logs in the database. The logs are basically time of user approach, duration of user with system, amount of information or type of information utilized.

5. Gesture Models used

A. MODEL 1: SEQUENCE GENERATION AND HOPFIELD ALGORITHM BASED GESTURE RECOGNITION

The 1D motion of hand gestures are left, right, up, down, these gesture having the axis of x and z only [12]. The MEMS sensor output is analog that is sign sequence, to determine the sign sequence. The x axis has the 4 codes, and z axis has the 4 codes so we choose the total sequence of gesture code is 8 number representations. In this sign sequence to encode the sequence as 1, -1 only [13].

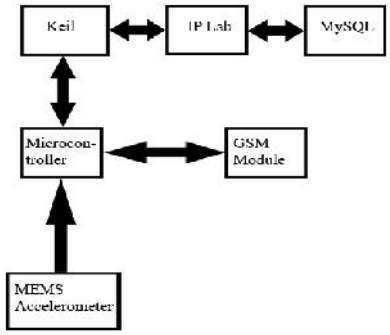

Fig. 1. Block Diagram

Before recognition, first gesture code is encoded so that Hopfield network should restore. Since the Hopfield network is only knows a “1” and “-1”, so we can encoded the sign sequence as positive sign, negative sign, zero signs are represented inthe format below,

• “1 1” is positive sign;

• “-1 -1” is negative sign;

• “ 1 -1” is zero sign.

Hopfield Network

The Hopfield algorithm consists of a set of N interconnected neurons. All neurons are both input and output neurons. Hence, by using the bidirectional associative memory (BAM) notations, the input layer Sx is the same with the output layer Sy. The involvement of Hopfield algorithm as a recovery mechanism makes the recognition algorithm more fault tolerant. When part of the input is lost or wrong, the network can still retrieve the most likely pattern which has been stored previously. First to use Hopfield algorithm to construct the weight [14].

B. MODEL 2: AREA SEQUENCE GENERATION BASED GESTURE RECOGNITION

This approach istoneardifferent feature which is the
velocity increment or the area bounded by the acceleration curve and x-axis, to implement classification [15]. According to the sign the acceleration is partitioned first. The area should decreases or increases at depend on the sign sequence. Before to store the data the area sequence is normalized to normalization is implemented using the formulae.

$$A_{norm} = \frac{A_{original}}{A_{max}}$$

C. MODEL 3: SEQUENCE GENERATION AND MATCHING FOUND BASED GESTURE RECOGNITION

The recognition algorithm of this model is very similar to that of model 1,there is no usage of Hopfield network. Hence encoding sign sequence into different combinations of 1's and -1's is not necessary. All the sign sequences are represented by 1,-1 and 0.

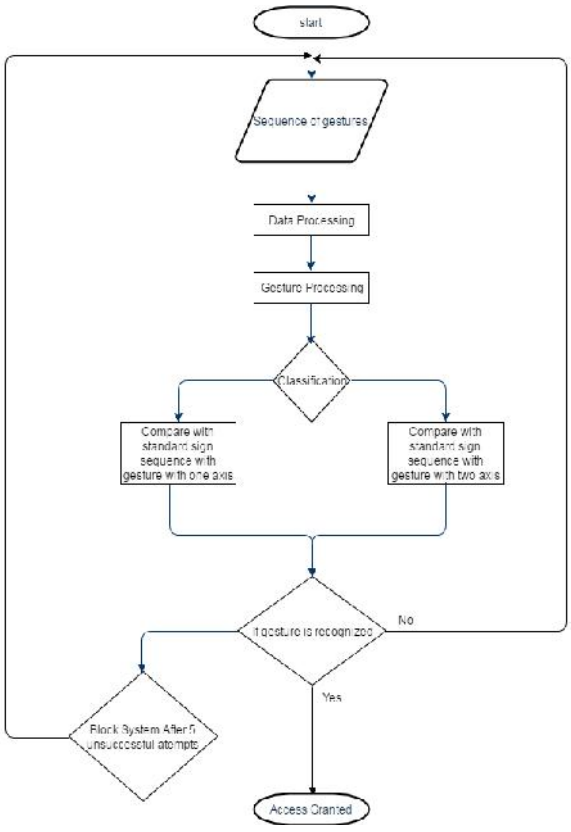

Fig. 2. Flow Chart

TABLE 1. COMPARSION OF HAND GESTURE RECOGNITION ACCURACY (%) [4]

	Up	Down	Left	Right	Mean
Model 1	91.20	90.3	86.0	87.50	88.75
Model 2	81.60	23.4	69.0	88.0	65.50
Model 3	97.64	94.11	95.29	96.70	96.00

6. Conclusion

This paper describes the security of a system using MEMS accelerometer to the user at remote places also. This paper also suggests the use of database for creating the logs of all the sessions taking place at the system and informing about it to the user remotely. The user can also operate the system from the remote place using same GSM module without moving towards the system.

7. References

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