Digital Pen Based on Trajectory Recognition Algorithm

Prachi S Muley, Dr. D.M .Yadav.

***Abstract*— This paper presents an accelerometer-based digital pen for handwritten digit and gesture trajectory recognition applications. The digital pen consists of a triaxial accelerometer, a microcontroller, and a wireless transmission module for sensing and collecting accelerations of handwriting and gesture trajectories. The proposed trajectory recognition algorithm composes of the procedures of acceleration acquisition, signal preprocessing, feature generation, feature selection, and feature extraction. Users can use the pen to write digits or construct hand gestures. The accelerations of hand motions calculated by the accelerometer are wirelessly transmitted to a computer for online trajectory recognition. The algorithm identifies the most important features by a PNN classifier algorithm for reducing the dimension of features**.

***Index Terms*—MEMS accelerometer, Microcontroller, handwritten gesture recognition, trajectory algorithm..**

I. INTRODUCTION

Now days the growth of small size technologies in electronic circuits and components has considerably decreased the dimension and weight of consumer electronic products, such as smart phones and handheld computers, and thus made them more useful and convenient. This method presents an accelerometer-based digital pen for handwritten digit and gesture trajectory recognition applications. Using this system we can do human computer interaction.

Recently, an alternative, a flexible embedded device with inertial sensors, has been expected to sense the activities of individual and to imprison their motion trajectory information from accelerations for handwriting and recognize gestures. The most important necessary benefit of inertial sensors for wide-ranging motion sensing is that they can be operating without any external reference and constraint in operating conditions. On the other hand, motion trajectory recognition is moderately hard for different users since they have different speeds and styles to generate a variety of motion trajectories. Thus, a number of researchers have tried to avoid the problem field for increasing the accuracy of handwriting recognition system. During this work a small MEMS accelerometer based recognition systems which recognize four hand gestures is constructed by using this four gestures, numerical data and alphabets will be recognized in the digital format.

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MEMS are termed as micro electro mechanical system. It uses the technology known as micro-fabrication technology. It has holes, cavity, channels, cantilevers, membranes and in addition imitates mechanical parts. The importance on MEMS is based on silicon. The explanation that prompt the use of MEMS technology are for example smallness of existing devices, expansion of new devices based on most important that do not work at large extent and to relate with micro world. It can efficiently reduce the cost by decreasing material consumption. It also increases applicability by reducing mass and size allowing placing the, MEMS in places where a traditional system.

In order to decrease the cost of systems and make straightforward the algorithms, much search effort has been dedicated to extract significant features from time-series inertial signals.

II. LITERATURE SURVEY

Recently, some studies have focused on the development of digital pens for trajectory recognition and HCI (human computer interface) applications. For instance, an alternative method of conventional tablet-based handwriting recognition has been proposed by Milner. In his system, two dual-axis accelerometers are mounted on the side of a pen to generate time-varying *X*- axis and *Y*-axis acceleration for handwriting motion. Following are some work related to hand gesture based digital pen.

Wang *et. al.* [1] presents a handwritten character recognition system based on acceleration. The character recognition system using a 3-dimensional (3D) accelerometer includes three procedures: Original signal detection, Signal processing (preprocessing and quantization) and Recognition/classification. In quantization procedure, Trajectory Orientation (TO) and Curve Feature (CF) are adopted and compared. In recognition procedure, Fully-connected Hidden Markov Model (HMM) and Left-Right HMM are both implemented and compared.

Many algorithms for gestures or characters recognition were studied, such as Hidden Markov Model (HMM), Bayesian Networks (BN) and Dynamic Time Warping (DTW). Since the objective to be analyzed could be either discrete or continuous, there exist two kinds of HMM, which are Discrete HMM (DHMM) and Continuous HMM (CHMM). The majority researchers use DHMM to find the most feasible activity state which is a lightweight one for math computation.

Shengli *et. al.* [2] presents a Micro Inertial Measurement Unit (IMU) based on Micro Electro Mechanical Systems

(MEMS) sensors is applied to sense the motion information created by characters written by human subjects. The work discussed in this paper focuses on human interactions with computing devices using characters and gesture recognition. There are two major character recognition methods based on different inputs: one is Optical Character Recognition (OCR), which gets data information by scanning the printed text; the other is Dynamic Character Recognition (DCR), which recognizes the characters based on their motion information, such as acceleration, angular velocity and so on.

Meenaakumari *et. al.* [3] presents an MEMS accelerometer which is based on gesture recognition algorithm and its applications. The hardware unit consists of a triaxial mems accelerometer, microcontroller, and zigbee wireless transmission module for sensing and collecting accelerations of handwriting and hand gesture trajectories. Users will use this hardware module to write down digits, alphabets in digital manner by making four hand gestures. The trajectory algorithm composed of information assortment collection, signal preprocessing for reconstructing the trajectories to satisfy the cumulative errors caused by drift of sensors. So, by changing the position of MEMS (micro electro mechanical systems) we can able to show the alphabetical characters and digits on the PC. The drawback of this system is that it can display the character or numbers in seven segment display format.

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Renuka *et al.* [4] proposed the Online Character Recognition system in which the character is processed while it was under creation. To capture the motions online, the general motion sensor, MEMS which can be operated without any external reference and restriction in working conditions is used. However, motion trajectory recognition is relatively complex because different users have different speed, pressure and strokes to generate a variety of motions. Thus many researchers have tried to narrow down the troubles for increasing the accuracy of handwriting recognition systems. By manipulating the acceleration signals and angular velocities of inertial sensors, some researchers have reduced the error of handwriting trajectory reconstruction. On the other hand, these trajectory reconstructions go through from different inherent errors due to the usage of inertial sensors.

Jeen-Shing *et. al.* [5] developed a pen-type portable device and a trajectory recognition algorithm. The pen-type portable device consists of a triaxial accelerometer, a microcontroller, and an RF wireless transmission module. The acceleration signals deliberate from the triaxial accelerometer are transmitted to a computer via the wireless module. Users can make use of this digital pen to write digits and make hand gestures at normal speed.

This paper has presented a methodical trajectory recognition algorithm structure that can construct efficient classifiers for acceleration-based handwriting and gesture recognition. The proposed trajectory recognition algorithm consists of acceleration acquisition, signal preprocessing, feature generation, feature selection, and feature extraction. With the reduced features, a PNN can be quickly trained as an effective classifier. In this paper they have used 2-D handwriting digits and 3-D hand gestures to authenticate the effectiveness of the projected device and algorithm.

III. PROPOSED SYSTEM

The pen device consists of a triaxial accelerometer microcontroller with a 10-b A/D converter, and a wireless transceiver. The triaxial accelerometer measures the acceleration signals generated by a user's hand motions. The microcontroller collects the analog acceleration signals and converts the signals to digital ones by using A/D converter. The wireless transceiver transmits the acceleration signals wirelessly to a personal computer (PC). The output of any axis is analog voltage which is directly proportional to the acceleration in that axis. Acceleration values can be positive, negative or zero. So, the output voltage has a zero bias output. The output given at this point means zero acceleration in that particular axis. So, the zero point voltage is greater than output voltage, it indicates the negative acceleration. The microcontroller integrates a high-performance 10-bit A/D converter and 8-b microcontroller unit (MCU) on a signal chip. The output signals of the accelerometer are sampled at 100 Hz by the 10-bit A/D converter. Then, all the data sensed by MEMS are transmitted to PC wirelessly by an RF transceiver, at 2.4-GHz transmission band with 1-Mb/s transmission rate. The overall power consumption of the digital pen circuit is 30 mA at 3.7 V.

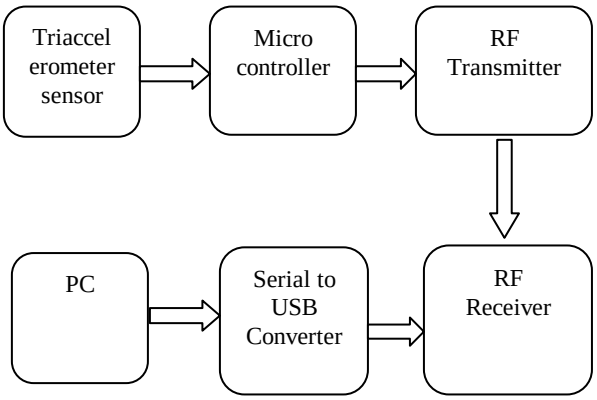

Figure1: Block diagram of proposed system

The MEMS sensors are available in various types such as Capacitive,Piezoelectric, Piezoresistive, Magneto-resistive, Heat Transfer, etc. Here in this project we are using capacitive sensor i.e.ADXL335.The ADXL335 is a small, thin, low power, complete 3 axis accelerometer. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The ADXL335 sensor is available in small package. It operates on supply of 1.8 V to 3.6 V

IV. TRAJECTORY RECOGNITION ALGORITHM

The acceleration signals of the hand motions are measured by a triaxial accelerometer and then preprocessed by filtering

and normalization. the features are extracted from the preprocessed data to represent the characteristics of different motion signals. To reduce the computational load and increase the recognition accuracy of the classifier, we
Utilize LDA to reduce the dimension of the selected features. Here introduce the detailed procedure of the proposed trajectory recognition algorithm as follows.

A. Signal Preprocessing

The raw acceleration signals of hand motions are generated by the accelerometer and collected by the microcontroller. Due to human nature, our hand always trembles slightly while moving, which causes certain amount of noise. The signal preprocessing consists of calibration, a moving average filter, a high-pass filter, and normalization. First, the accelerations are calibrated to remove drift errors and offsets from the raw signals. The second step of the signal preprocessing is to use a moving average filter to reduce the high-frequency noise of the calibrated accelerations.

B. Feature Generation

The characteristics of different hand movement signals can be obtained by extracting features from the preprocessed *x*-, *y*-, and *z*-axis signals, and instead of extracting features from the triaxial acceleration signals, including mean, STD, VAR, IQR correlation between axes, MAD, rms here, we extract two dominating features such as Zero crossing and Range.

C. Feature Selection

Feature selection comprises a selection criterion and a search strategy. In this zero crossing and range feature is selected for further computation.

D. Feature Extraction

For pattern recognition problems, LDA is an effective feature extraction (or dimensionality reduction method) which uses a linear transformation to transform the original feature sets into a lower dimensional feature space. The purpose of LDA is to divide the data distribution in different classes and minimize the data distribution of the same class in a new space.

V. ALGORITHM FOR PROPOSED SYSTEM

The entire system process is explained below in detail by step by step process.

Step 1: The motion of accelerometer in any direction is send to microcontroller in form of raw signal in (1x80 vector) through wire connection.
Step 2: These values then pass through the process of calibration.
Step 3: Then the values are processed through moving averaging filter to make (1x20 vector) average values.
Step 4: The high pass filter processes this data.
Step 5: The data then pass through process of Normalization.
Step 6: After this features extraction is done (zero crossing & Range)
Step 7: Here we use serial to USB communication for fast response.
Step 8: Using Matlab software PC displays the motion in terms of character or digit or hand gesture.

VI. DISCUSSION

This paper has presented a systematic trajectory recognition algorithm framework that can construct effective classifiers for acceleration-based handwriting and gesture recognition. The proposed trajectory recognition algorithm consists of acceleration acquisition, signal preprocessing, feature generation, feature selection, and feature extraction.

VII. FUTURE SCOPE

The development of the portable device is used to generate desired commands by hand motions to control electronic devices without space limitations. The acceleration made by the hand motion is measured by the accelerometer are wirelessly transmitted to the computer. The proposed system uses single stroke handwriting algorithm.

The Digital pen can be use for multi stroke handwriting by making some modifications in algorithm. With the multistroke handwriting user can write the full sentence with normal speed. In this system the pen section can be interface with microcontroller wirelessly or microcontroller can be installed inside pen section by using system on chip technology to fabricate a microchip.

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