Motion Pattern Sensing Using Compact MEMS Transducer Based Pen

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ABSTRACT
This paper gives a broad idea about Motion Pattern Sensing Using Compact MEMS Transducer Based Pen. The digital pen consists of a 3 axes MEMS based accelerometer, a microcontroller, and wireless transmitter-receiver unit for sensing and pocketing accelerations of hand motion patterns. The pattern sensing algorithm compiles of the procedures of sensor acquisition, signal analysis, pattern recognition and feature classification. The software is proficient of converting time based motion signals into important pattern based vectors. The pen is use to write numbers or make hard motion while the acceleration of hand movements measured by the MEMS transducer are transmitted to a computer by RF signals for online trajectory pattern generation. The algorithm initially takes outline of the frequency and time domain aspects from the transducer signals and later, classifies the critical features by a method: kernel based class dissection for pointing out key features and linear differential analysis for attenuation the structural dimension of features. These be spoken processed features are sent to a probabilistic network for further analysis.

Keywords: Accelerometer, gesture, probabilistic neural network (PNN), handwritten recognition, linear discriminate analysis (LDA).

1. INTRODUCTION
The devices such as smart phones and handheld computers are made compatible and more suitable due to the pick development of computer technology, because of which Human–computer interaction (HCI) techniques have become a necessary component in our day today life. In this technology based life, an well turned-out selection of a portable device embedded with inertial sensors has been used, which wits the activities of a human and to capture his/her motion trail information with accelerations for recognizing gestures or handwriting. There is a significant advantage of inertial sensors for general motion sensing that is, they can work on circumstances. On the other hand, motion trajectory recognition is relatively complicated as different users have different speeds and styles to generate a variety of motion trajectories. Because of this, many researchers have tried to tackle the problem domain to increase the accuracy of handwriting recognition systems. Some researchers recently have taken steps in reducing the error of handwriting trajectory reconstruction by manipulating the acceleration signals and angular velocities of inertial sensor. However, the redeveloped trajectories are moving from various fundamental errors of inertial sensors. Due to which, many researchers have stressed on developing effective algorithms for error reimbursement of inertial sensors; in order to improve the recognition accuracy of a proposed pen type input device to track trajectories in 3-D space; by using accelerometers and gyroscope. A more proficient acceleration error compensation algorithm based on zero velocity compensation was developed to reduce acceleration errors for acquiring accurate reconstructed trajectory. An extended Kaman filters with magnetometers (micro inertial measurement unit) are used to compensate the orientation of the proposed digital writing instrument .Orientation of the instrument being estimated precisely, the motion trajectories of the instrument were re-constructed accurately. A method of optical tracking calibration is proposed based on optical tracking system (OTS) to calibrate 3-D accelerations, angular velocities, and space attitude of handwriting motions. The OTS was developed for the following two goals, to obtain accelerations of the proposed ubiquitous digital writing instrument (UDWI) by calibrating 2-D trajectories and to obtain the accurate attitude angles by using the multiple camera calibration. On the other hand, in order to recognize or reconstruct motion trajectories accurately, therefore mentioned approaches introduce other sensors such as gyroscopes or magnetometers to obtain precise orientation, which increases additional cost for motion trajectory recognition systems as well as computational burden of their algorithms.

To reduce the cost of systems and simplify the algorithms, many research efforts have been devoted to derive important features from time-series inertial signals. To name computed correlation coefficients of the absolute value of acceleration. Also the absolute value of the first and second derivatives of acceleration to form feature vectors. Principal component analysis (PCA) was then applied and Fisher linear discriminates to reduce the dimension of the feature vectors. With the reduction in features, a time-lagged feed forward network is
Made to recognize 2-D handwriting gestures and the best performance with an overall accuracy of 95% in the acceleration, velocity, and position features were generated from raw acceleration signals, and then, the PCA was utilized to reduce the feature dimension size [5]. They successfully employed a hidden Markov model (HMM) with dynamic time warping algorithms to recognize 3-D handwriting digits with time- and frequency-domain features (such as mean, variance racy of 86 %) [7]. Correlation, spectral entropy, and spectral energy of worn simultaneously on different positions of a participant’s hand. Subsequently, the AdaBoost, HMM, and k algorithm were utilized to classify hand motions, and the AdaBoost. Classifier achieved the best performance with an overall accuracy of 86% [11]. Thus Human–computer interaction (HCI) techniques have become an indispensable component in our daily life. A portable device embedded with inertial sensors, 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. The error of handwriting trajectory reconstruction reduced by manipulating acceleration signals and angular velocities of inertial sensors to developed effective algorithms for error compensation of inertial sensors to improve the recognition accuracy.

A pen type input device to track trajectories in 3-D space by using accelerometers. An efficient acceleration error compensation algorithm based on zero velocity compensation has developed to reduce acceleration errors.

2. LITERATURE SURVEY

Earlier have focused on the development of digital pens for trajectory recognition and HCI applications. The GSM Modem can be connected for SMS alerting sensor can be used for security in our study and we assume that an additional button can be used to allow users to indicate the starting point and ending point of motion. Due to which, the limitation of the proposed trajectory recognition algorithm is that it can only recognize a letter or a number finished with a single stroke. GSM Modem can be connected for SMS alerting sensor can be used for security in our study and we assume that an additional button can be used to allow users to indicate the starting point and ending point of motion. Thus, the limitation of the proposed trajectory recognition algorithm is that it can only recognize a letter or a number finished with a single stroke. We are currently developing algorithms for letters or words with multistoried which involve more challenging problems.

3. HARDWARE DESIGN OF DIGITAL PEN

The hardware mainly consists of four major blocks as 1) PC-Serial Interface 2) AVR Micro-Controller 3) LCD Module. Please refer the schematic as shown in Fig.

3.1.1. Lab View Set-Up

The Lab View set-up gives a graphical representation of the entire system consisting of the user Interface, capable of handling and responding to commands sent by the user Interface.
3.1.2. Accelerometer
The ADXL335 is a small, thin, low power, complete 3 axis accelerometer. This product has a small package and can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. Single-supply operation is between 1.8V to 3.6V. Please refer the breakout image as shown in Fig. 2.

![Module of MEMS Accelerometer ADXL355](image_url)

3.1.3. AVR Micro-controller
There are many techniques available to implement touch key technology for the bespoke section. Few important features are available in AVR micro-controller which are 1) High performance, low cost, Low-power AVR® 8-bit Microcontroller 2) RISC Architecture 3) Low power consumption 4) Supports RF protocol 5) Supports SPI and I2C™ Master and Slave modes 6) 10-Bit, up to 11-Channel Analog-to-Digital 7) Converter module (A/D)

3.1.4. RF Module
The aim is to select the RF Module best suited for this particular application. Few important features are available are 1) Low power consumption 2) Integrated data filters 3) High sensitivity 4) Operation temperature range between -40~+85°C 5) Available frequency between 2.4~2.483 GHz- No certification required from government 6) High accuracy 7) Low cost

3.1.5. LCD Module
In market various displays are available like 7-segment, 5*7 matrix LED and LCD, bar graph, LCD, etc. It’s important for deciding the required display set for our project. Display selection depends on various factors like power consumption, ambient light conditions, surrounding temperature, visibility from long distance, total information to be display, cost of display, circuit/lines required for display interfacing, etc. The usual way to accomplish this is with the LCD (Liquid Crystal Display). LCDs have become a very cheap and easy way to get text display for an embedded system.

Here in this project we require a 16X2 LCD to display the status of modules. In this system we prefer to choose a LCD instead of LED or 7-Seg display because it has the ability to display numbers, characters and graphics whereas LED displays are limited to numbers and a few characters. Refreshing display characters by the controller is less in the LCD which reduces the overhead of the CPU. It is easier to program characters and graphics on LCD.

This shows the basic pin diagram of 16*2 LCD display. There are 8 lines for the data transfer between microcontroller & LCD. In order to control the LCD operation, three control signals are used 1) ENABLE (EN): It is used to enable the display to perform any operation with it 2) R/W (Read/Write): This signal indicates to LCD processor that the operation being performed is read operation else write operation. If it is 1 it indicates the read operation & if it is 0 it indicates the write operation. 3) RS (Register Select): There are two types of registers as Command register & data register. To select one of these registers RS signal is used. If it is 0 the command register will be get selected & if it is 1 the data register will be selected.

3.1.6. RS232 Transceiver
While using the minimum recommended capacitor values, it is made sure that the capacitance value does not degrade excessively as the operating temperature varies. If doubt, we use capacitors with a larger (e.g., 2x) nominal value. The capacitors’ effective series resistance (ESR), which usually rises at low temperatures, which in turn influences the amount of ripple on V+ and V-. With use larger capacitors (up to 10µF) we reduce the output impedance at V+ and V-. This can be useful when we are “stealing” power from V+ or from V-.
4. TRAJECTORY RECOGNITION ALGORITHM

The proposed trajectory recognition algorithm composes of the procedures of acceleration acquisition, signal pre-processing, feature generation, feature selection, and feature extraction. The algorithm is capable of translating time-series acceleration signals into important feature vectors. Users can use the pen to write digits or make hand gestures, and the accelerations of hand motions measured by the accelerometer are wirelessly transmitted to a computer for online trajectory recognition.

![Block diagram of the trajectory recognition algorithm](image)

The algorithm first extracts the time- and frequency-domain features from the acceleration signals and, then, further identifies the most important features by a hybrid method: kernel-based class reparability for selecting significant features and linear discriminate analysis for reducing the dimension of features. The reduced features are sent to a trained probabilistic neural network for recognition. The block diagram of the proposed trajectory recognition algorithm consisting of acceleration acquisition, signal preprocessing, feature generation, feature selection, and feature extraction is shown in Fig. 3. In this paper, the motions for recognition include numbers and eight hand gestures. The acceleration signals of the hand motions are measured by a triaxial accelerometer and then preprocessed by altering and normalization. Consequently, the features are extracted from the preprocessed data to represent the characteristics of different motion signals, and the feature selection process based on KBFS picks features out of the original 24 extracted features. To reduce the computational load and increase the recognition accuracy of the classifier, we utilize LDA to reduce the dimension of the selected features. The reduced feature vectors are fed into a PNN classifier to recognize the motion to which the feature vector belongs.

The proposed trajectory recognition algorithm is used in the following steps:

- **Step 1)** Acquire the unrefined acceleration signals from the pen type accelerometer module.
- **Step 2)** This unrefined signal is calibrated with standard result and match the signal coming from pen type accelerometer module with that result further for detect noise from that result.
- **Step 3)** Filter out the high-frequency noise of the unrefined accelerations by the moving average filters in (1) and then removes the gravity from the filtered accelerations by a high-pass filter.
- **Step 4)** Finally; normalize each segmented motion interval into equal sizes via interpolation.
- **Step 5)** After normalization this signal test for feature generation and generate the time- and frequency-domain features from the preprocessed acceleration of each axis.
- **Step 6)** According the time- and frequency-domain features from the preprocessed acceleration of each axis to select significant features by KBFS.
- **Step 7)** Reduce the dimension of the selected features by LDA.

CONCLUSIONS

The work for the light guide has been initiated and the light guide prototypes are available. The Lab View system is developed for basic functionality and progress with time. The task is to develop a pen-type portable device and a trajectory recognition algorithm. Currently we develop 2-D handwriting digits and 3-D hand gestures to validate the effectiveness of the proposed device and algorithm. The overall handwritten digit recognition rate should be high using our digital pen as an effective tool for HCI applications. We can use this digital pen to write digits and make hand gestures at normal speed. The measured acceleration signals of these motions can be recognized by the trajectory recognition algorithm.

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REFERENCES

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