ISSN 2349-4506
Impact Factor: 2.265

Global Journal of Engineering Science and Research Management

# A REVIEW PAPER ON INERTIAL SENSOR BASED ALPHABET RECOGNITION USING CLASSIFIERS

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**KEYWORDS:** Inertial sensors, trajectory recognition, PNN classifiers.

## ABSTRACT
In today's computer world human computer interface is important part. Pen with inbuilt inertial sensors" are new instruments in industry that may completely replace the computer keyboard. These devices aim to capture human handwriting or drawing motions in 3D space in real-time and use the sensor data for recognition or information retrieval at a later time.

The proposed An inertial sensor based "Inertial pen" for handwritten character and gesture trajectory recognition consist of a microcontroller, and an RF wireless transmission module for sensing and collecting inertial sensor data of handwritten alphabets. Trajectory recognition algorithm composes of the procedures of sensor data acquisition, signal pre-processing, feature generation, feature selection, and feature extraction. Users can use the pen with inertial sensors to write alphabets, data is wirelessly transmitted to a computer for online trajectory recognition. The algorithm is capable of translating time-series sensor signals into important feature vectors. These vectors are used as input to classifiers.

## INTRODUCTION
Efforts are always made to find different methods for convenient human -machine interaction. Gesture recognition is becoming a desirable technology, enabling humans and machines to interface more easily in natural way.

There are two main types of gesture recognition approaches which are getting more focus from researchers, Vision based approach and capture of motion by sensors. As compared to sensor based approach Vision based approach is expensive, needs large data processing and slower dynamic response.

Researchers used one or two, three axial accelerometer, to obtain data for gesture recognition. But for character /alphabet recognition due to minute variation in sensor data for different characters, character recognition becomes challenging. Therefore to obtain quality motion data for character recognition, along with triaxial accelerometer, triaxial gyroscope to measure angular movement and magnetometer to measure direction of movement s used.

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Use of combination sensors is increasing rapidly develop intelligent electronic devices. IMU, inertial measurement unit, is a term used in the MEMS industry to refer to a 6-axis or 9-axis combination with sensor fusion software. Sensor fusion software intelligently combines data from the individual sensors within the combination product for the purpose of improving application or system performance.

## PROPOSED SYSTEM

The block diagram of the system implemented is shown in fig.1

The microcontroller collects the digital accelerations, angular velocities, and magnetic signals, and transmits the above mentioned inertial signals to a PC main processor for further signal processing and analysis. When the user draws some pattern on the paper or makes some gestures in 3-D space by using this Inertial pen, the inertial pen acquires the inertial signals produced and transmits them to the PC. This transmitted data is nothing but the X, Y and Z Directional signal produced by each sensor i.e. Accelerometer, Gyroscope and Magnetometer. Thus, there is a set of 9 values transmitted by the inertial pen hardware to the PC. A signal processing analysis and software system built using MATLAB acquires those signals and Recognizes the pattern drawn by the user by using our character recognition algorithm.

This Inertial pen, acquires the acceleration, gyroscope and magnetometer signals and transmits them to the PC. This transmitted data is nothing but the X, Y and Z Directional acceleration, angular and positional data. Thus, there is a set of 9 values transmitted by the inertial pen hardware to the PC at every instant.

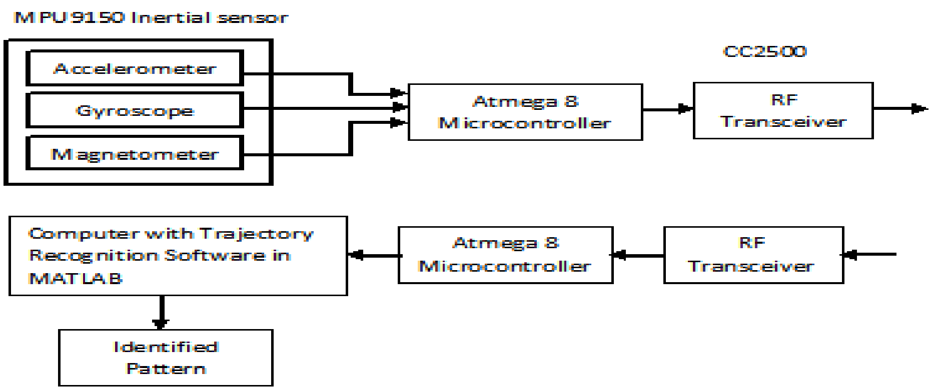


*Fig.1 System Block Diagram*

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The software system consists of following main blocks as:

**Signal Pre-processing:**

The software gets the inertial signal values along X,Y and Z directions at every instant from the digital pen. The purpose of pre-processing and normalization methods is to simplify the recognition task by reducing the amount of information, eliminating imperfections, and removing uninformative variations in handwriting data.

Calibration is the process of defining the X,Y and Z values in zero acceleration state i.e. stable state. During calibration, the Digital Pen is held in the hand in stable position. The X, Y and Z acceleration values in this state are the zero acceleration values. All the acceleration values are measured with respect to these values. The accelerations are calibrated to remove drift errors and offsets from the raw signals.

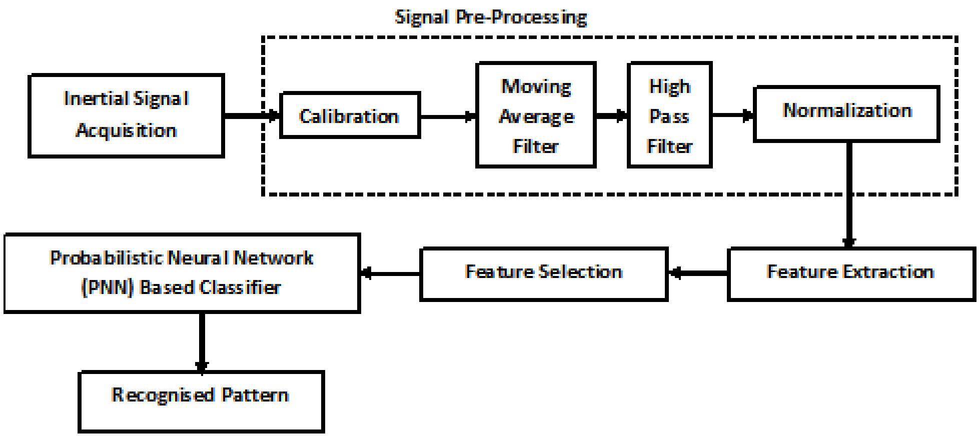


***Fig.2 Software system Block Diagram***

Second step of the signal pre-processing is to use a moving average filter to reduce the high-frequency noise. Normalization is nothing but mapping all the input values in some particular range e.g. -2 to 2.

2)Feature generation And feature selection : Mean, STD(Standard Deviation), VAR (variance), IQR (Interquartile range) , MAD(median) , rms( root mean square value) range and number of zero crossing are extracted. Then the features not useful for distinguishing alphabet are discarded. Obtained feature values are given to PNN classifier.

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## LITERATURE REVIEW

**An accelerometer based Digital pen with trajectory trajectory Recognition Algorithm for Handwritten Digit and Gesture Recognition"**

Jeen-Shing Wang, and Fang-Chen Chuang presented [1]an accelerometer-based digital pen for handwritten digit and gesture trajectory recognition trajectories. The proposed trajectory recognition algorithm of consists of acceleration acquisition, signal pre-processing, feature generation, feature selection, and feature extraction. The algorithm first extracts the time- domain features from the acceleration signals and, then, further identifies the most important features by a hybrid method: kernel-based class separability for selecting significant features and linear discriminant analysis for reducing the dimension of features. The reduced features are sent to a trained probabilistic neural network (PNN) for recognition.

Trajectories of Arabic numerals were drawn by five males and five females with, the pen tip must touch a table. Signals acquired from the accelerometer module is calibrated to detect the start and end point, then are filtered via the moving average filter to reduce the high-frequency noise. The gravitational acceleration was removed from the filtered acceleration signals via a high-pass filter to obtain the accelerations caused by hand movement. From the pre-processed accelerations, 24 features are generated by the feature generation procedure. Then KBCS is applied to choose most distinguishing features from the generated features.

The features generated includes mean, STD (Standard Deviation),, VAR (variance), IQR (Interquartile range) , MAD(median) , rms( root mean square value), and energy. From analysis it is found that STD and VAR features are having same values for different digits hence not much useful to distinguish them.
There were 11 significant features including corrxz,(correlation between xz) meanx, meany, MADx, IQRx, rmsx, corrxy, meanz, energyx, energyy, and energyz selected from 24 features by the KBCS. Finally, the dimension of the selected features was further reduced to nine by the LDA .It eases computational load and also to increase the accuracy of classifier.

**GyroPen: Gyroscopes for Pen-Input With Mobile Phone**

Today's smartphones are equipped with inertial sensors. The use of mobile phones as input device [2] for trajectory reconstruction was proposed by Thomas Deselaers, Daniel Keysers, Jan Hosang, and Henry A. Rowley. Smartphone with inertial sensors termed as, 'Gyro pen,' is connected to handwriting recognition system for text entry. It is promising approach as text entry is still tedious due the fact that a human finger is thicker than a typical key on the virtual keyboard on touch screen. The user can hold the mobile phone corner like a pen and "write" on any surface The trajectory of the phone's "writing corner" is reconstructed from the phone's sensors .The use of inertial sensors(accelerometer and gyroscope ) of smartphone removes the necessity for accurate absolute 3-D position estimation, which is difficult using low-cost accelerometers, so we can directly use the angular trajectory for reconstruction/recognition.

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To measure the reconstruction error, both paths i.e actual path and reconstructed paths for 13 words were aligned using a dynamic programming algorithm similar to the one used for stereo reconstruction. Comparison showed an average deviation between reconstruction and the actual path less than 4% relative (5% standard deviation) to the length of the path.

**"MEMS Accelerometer Based Nonspecific-User Hand Gesture Recognition.**
Ruize Xu, Shengli Zhou, and Wen J. Li, in [5] presented simple three gesture recognition models and compared their performances for recognizing seven hand gestures, viz up, down, left, right, tick, circle, and cross, received from 3-axes accelerometer. The three models 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. These models are based on motion analysis of seven gesture. It propose that the exact shape of the acceleration curves is not important , but only the alternate sign changes of acceleration on the axes are required to uniquely differentiate any one of the 7 gestures.


For example the gesture up has the 1) acceleration 1-3 acceleration on z-axis is negative (since positive z direction is downward); velocity changes from zero to a maximum value at 3; acceleration at point 3 is zero.

2) 3- 4: acceleration on z-axis is positive, velocity changes from negative to positive and is maximum at point 4, where acceleration becomes zero.

3) 4 1: acceleration on z-axis is negative; velocity changes from positive to zero. Also, acceleration and velocity become zero at point 1. Experiments showed that each of these gestures has special order of sign changes,

ISSN 2349-4506
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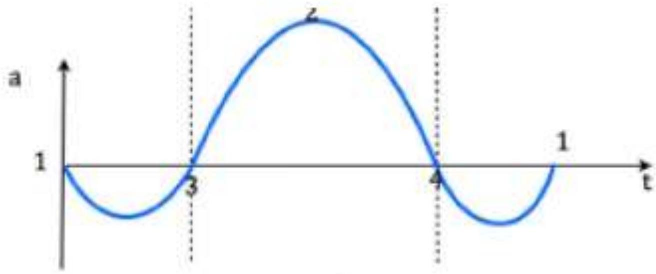


***Fig.:3 Variation in acceleration***

It was found that each of seven gestures has unique acceleration patterns for classification.
The three model consists of data processing and segmentation as pre-processing.

In model one, when part of the input is lost or wrong, then the network will help to restore the gesture code to the correct pattern by constructing weight matrix.

In Velocity increment mode, acceleration pattern can be represented by areas in alternate signs. These areas indicates the increase or decrease in velocity. This approach is good for complex gestures.

Model three is same as that of first model except instead of Hopfield network template matching is used.sign sequence and template matching based gesture recognition model gave best results for seven gesture.

**Online Handwriting Recognition Using an Accelerometer- Based Pen Device**
Jeen-Shing Wang, Yu-Liang Hsu, Cheng-Ling Chu in their paper [3] presented character recognition for online handwriting recognition. Offline recognition refers to recognition of the images of handwritten characters while online recognition recognizes the stroke trajectories of handwritten characters. Authors also presented an accelerometer-based pen like device [1] to obtain the coordinate information of the pen tip as functions of time but dynamic time wrapping algorithm for digit recognition.

An automatic recognition algorithm used for 3D handwritten digit trajectories recognition consists of Signal pre-processing and DTW recognizer.

The signal pre-processing procedure was carried out by calibration, a low pass filter, segmentation, and normalization. Calibration was used to offset and reduce errors of sensitivity of accelerometers. A low pass filter was used to remove

ISSN 2349-4506
Impact Factor: 2.265

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high-frequency noise from the raw data. Then, an adaptive magnitude threshold is used to segment the acceleration patterns of hand movements when writing numerals in a 3-D space. Finally, the amplitude of each acceleration pattern has been normalized to the interval [0, 1] to avoid extreme amplitude scaling.

A dynamic time warping (DTW) algorithm is applied to align the accelerations and search class templates for each digit in the training stage. Finally, the accelerations are recognized via the alignment with the class templates in the testing stage. During the experiment, the ten participants were asked to write ten digits using pen device (embedded with accelerometer). The minimum selection method presented is used to perform the template selection .The sum of the DTW distance between the template and all other patterns within the same class is calculated. Then, the pattern with the minimum intra-class DTW distance is selected as the class template.

There is only one class template for each digit by using the DTW recognizer. Finally, in the testing stage of the DTW recognizer, the recognition results are obtained through the DTW recognizer by measuring the similarity between the testing data and the selected class templates.

The average user-dependent and user independent recognition rates were 90.6% and 84.8%, respectively. The authors identified the main reason of misrecognition is similarity of temporal pattern of different digits.

**Air writing Recognition using Wearable Motion Sensors**
Christoph Amma, Dirk Gehrig, Tanja Schultz presented a wearable input device which enables the user to input text into a computer. The text is written into the air via character gestures, like using an imaginary blackboard. To allow hands-free operation, a data glove, equipped with three gyroscopes and three accelerometers to measure hand motion was designed and implemented. Data is sent wirelessly to the computer via Bluetooth.

HMMs is used for character recognition and concatenated character models for word recognition.

## CONCLUSION

From literature survey highest gesture (4-6 gestures) and digit (0-9) recognition accuracy is obtained by using dynamic time wrapping algorithm which based on template matching. But as the no. of gestures to be recognised increases and there is minute variation in patterns of different gestures, recognition accuracy with template matching reduces. Therefore to implement the character recognition system based on gesture/pattern recognition, training and testing the classifiers with selected feature vectors approach is used. Characters to be recognized are English capital alphabets.
The performance or recognition accuracy of the algorithm also depends mainly on the features generated and features selected. Since features hold characteristics of alphabet /character. So the focus in the project will be to find the most promising features which will accurately distinguish the characters. Performance by different set of features is compared by using two classifiers PNN and KNN.

ISSN 2349-4506
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