An Inertial Sensing base Pen for Handwriting and Gesture Recognition using Adaptive Dynamic Time Wrapping Algorithm

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Abstract— *In this paper we are going to present an inertial sensing base pen which will identify the gesture and handwriting of the person with the help of adaptive dynamic time wrapping algorithm. When any user hold the inertial pen to write any word with his preferred style then the signal are sense via. The sensors that are mounted on the inertial pen and are send wirelessly to the computer through trans-receiver, than the adaptive dynamic time wrapping algorithm (ADTW) is used for recognition of the written word. The ADTW algorithm includes the process of signal acquisition, signal pre-processing, motion detection, template selection and recognition. We also use the filter to reduce the error caused by the noise or signal drift over the collected signal from accelerometer, gyroscope and magnetometer. We also have used min-max template selection method for ADTW recognition to obtain a fine class separation for improved recognition. We have successfully validated the effectiveness of ADTW recognition through inertial pen for handwriting gesture recognition for English alphabet, signature, and English sentence.*

Keywords— Inertial Pen, Adaptive Dynamic Time Wrapping Algorithm, Filters Gesture Recognition, Handwriting Recognition

I. INTRODUCTION

With the rapid development of computer technology human computer interaction technique/devices have become indispensable in individuals daily lives. The ease with which an HCI device or technique can be understood and operate by users has become one of the major consideration when selecting such devices. Recently, an attractive alternative, a portable device embedded with inertial sensor, has been proposed to sense the activities of human and to capture their motion acceleration for recognizing gesture or handwriting among those methods pen based input device embedded with accelerometer, gyroscope can most easily provide intuitive expression through capturing translation acceleration and angular velocity generated. The portable inertial pen is composed of a triaxial accelerometer, a triaxial gyroscope, a triaxial magnetometer, a microcontroller, and an RF wireless transmission module. User can utilized this inertial pen to write numerical or English letter, and make hand gesture at their preferred speed without space limitation. Measured acceleration, angular velocity and magnetic signals are transmitted to a pc via RF wireless module.

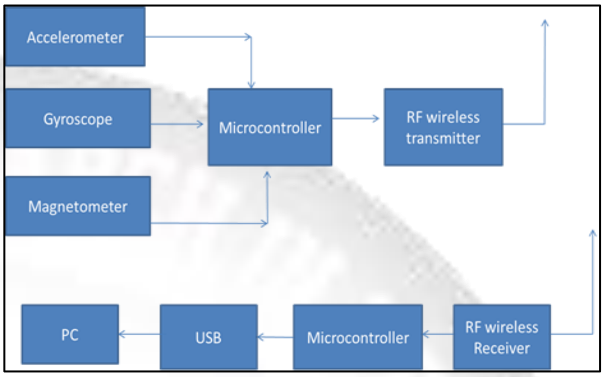


Fig. 1: Block Diagram for Inertial Pen

II. ADAPTIVE DYNAMIC TIME WRAPPING ALGORITHM

Pattern developed from time series is of fundamental importance. The dynamic time warping is a technique that allows local flexibility in aligning time series. Because of this, it is widely used in many fields such as science, finance, medicine, industry and others. However, a major problem of the dynamic time warping is that it is not able to work with structural changes of a pattern. This problem arises when the structure is influenced by noise, which is a common thing in practice for almost every application. The pattern structure which arises due to influence of noise problem is a common thing in practice for almost every application. The standard DTW approach uses only information about fixed pattern points and not structural elements between these points. This paper addresses this problem by means of developing a novel technique called adaptive dynamic time warping (ADTW).

The designed Adaptive DTW (ADTW) where the contributions of global features and local features are leveraged. The weighting factors are learned from the training data by a newly designed feature selection algorithm. The ADTW therefore enhance the capacity of supervised learning for time series data. The algorithm defines an in-class range for each sequence in the training set as the distance between this sequence and the farthest sequence in the same class. Then for each training sequence, it calculates the difference between the number of same-class sequences within the in-class range and the number of different-class sequences within the in-class range. Finally the value of the normalized accumulated differences among all the training sequences is used as the value of the weighting factor for the corresponding feature.

III. Hardware and its Working

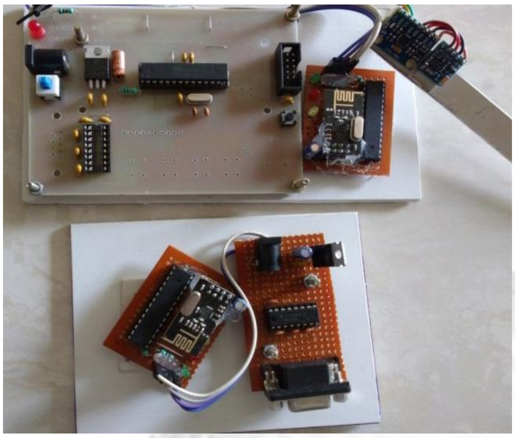


Fig. 2: Complete Device for Inertial Pen

This device will work in two phase they are.

A. *Training*

In this section we train our device with no. of samples input, i.e.; we will ask to write English sentences, signature etc. all this samples will be saved with individual name. First of all we will power on our device and pc. And then run the matlab code designed for our devices from our pc, the first window that appears to us is as shown in figure. As we are training our device we will first collect all the data with us as a data base of different persons. Every time we need to select an option create data base from option menu,

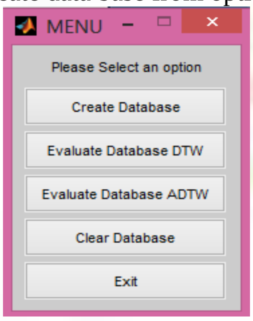


Fig. 3: Snap of Menu

After selecting the create database option from menu the next window that appears to us is as shown in figure 28. It ask us to press ok if we are ready to give input through pen, user need to press ok once he is ready with the inertial pen to write something.

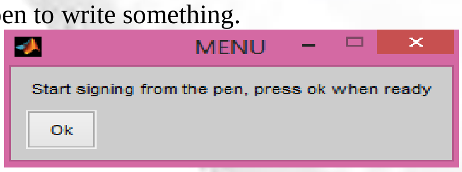


Fig. 4: Snap of Menu

This option indication tells us that the transmitting section of the device is ready to transmit the data and receiver is ready to receive the transmitted data. Once ok is press the written data is capture as features from three different sensors and send to the receiver which is connected to pc. All this procedure is repeated no. times we need to create data base. The bellow figure gives the snap of the written word “a” by particular person, once the data is written the transmition and reception of signal stops. Than we are ask to store that particular written data against that person’s name, the next window that appears to us is to save the created features with some name as shown is figure.

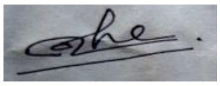


Fig. 5: Snap of Data Base Stored

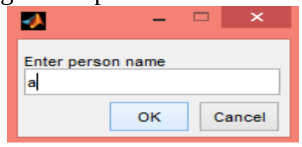


Fig. 6: Snap of Menu to Save Database

We get the 9 features for each sampling three values for acceleration, three values for angular acceleration, and three values for magnetic pressure, as we are maintaining 50Hz sampling so in all we will get 9x50 = 450 values for each training samples or data base we stores with us. Bellow figure gives the particular reading and its equivalent feature vector graph.

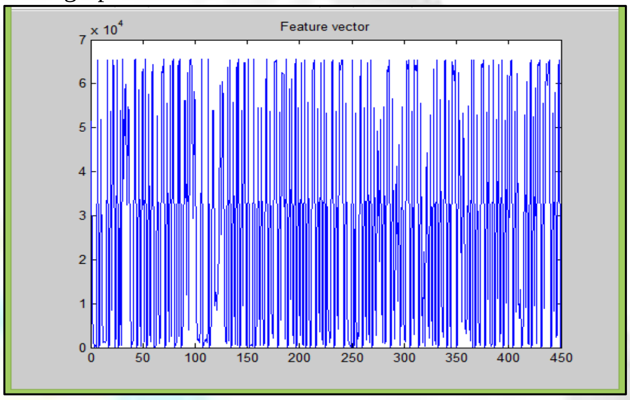
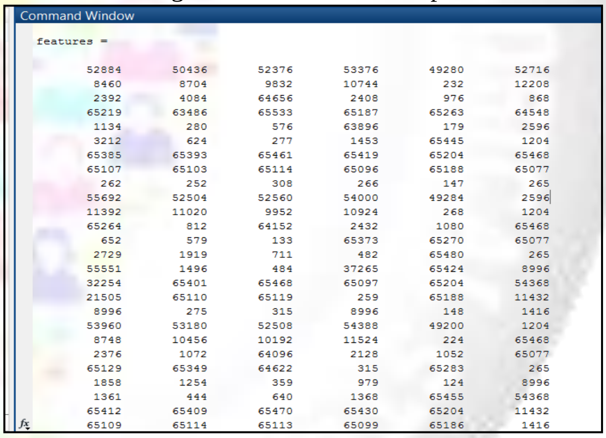


Fig. 7: Feature Vector Graph



Command Window

features =

52884	50436	52376	53376	49280	52716
8460	8704	9832	10744	232	12208
2392	4084	64656	2408	976	868
65219	63486	65533	65187	65263	64548
1134	280	576	63896	179	2596
3212	624	277	1453	65445	1204
65385	65393	65461	65419	65204	65468
65107	65103	65114	65096	65188	65077
262	252	308	266	147	265
55692	52504	52560	54000	49284	2596
11392	11020	9952	10924	268	1204
65264	812	64152	2432	1080	65468
652	579	133	65373	65270	65077
2729	1919	711	482	65480	265
55551	1496	484	37265	65424	8996
32254	65401	65468	65097	65204	54368
21505	65110	65119	259	65188	11432
8996	275	315	8996	148	1416
53960	53180	52508	54388	49200	1204
8748	10456	10192	11524	224	65468
2376	1072	64096	2128	1052	65077
65129	65349	64622	315	65283	265
1858	1254	359	979	124	8996
1361	444	640	1368	65455	54368
65412	65409	65470	65430	65204	11432
65109	65114	65113	65099	65186	1416

Fig. 8: Features Reading

B. *Testing*

Here the new input data is taken from any person of the previously stored name and its feature are compared with the previously stored samples feature using ADTW algorithm. And the best match with minimum feature difference is given as output to us.

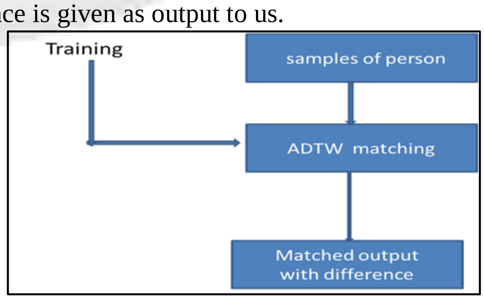


Fig. 9: Block Diagram of Testing

In the testing process we will be checking the newly taken data with our stored database, here our algorithm is used to identify the best match among the stored database. The process for testing is, first we will power on our device and PC, and then run the matlab code same way as done for training, but hear we need to select the option evaluate database using ADTW from the select menu option as shown in figure.

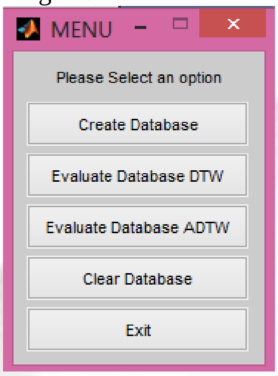


Fig. 10: Scren Shot of SelectMenu

After selecting this option the next menu opens is ot select ok and start signing in from inertial pen.

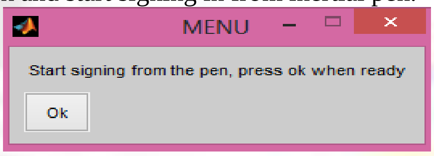


Fig. 11: Scren Shot of Menu

When user start writing from pen the features generated, are matched with the previously stored database using ADTW algorithm and the best match is found of the stored database with diffrence of some value. while evaluating database for the writen data are as shown in figure.

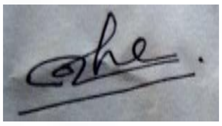


Fig.12 - Input Data For Evaluation.

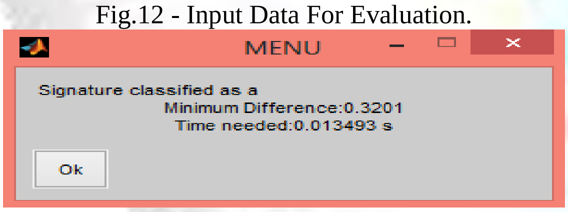


Fig. 13: Classification Menu With Diffrence

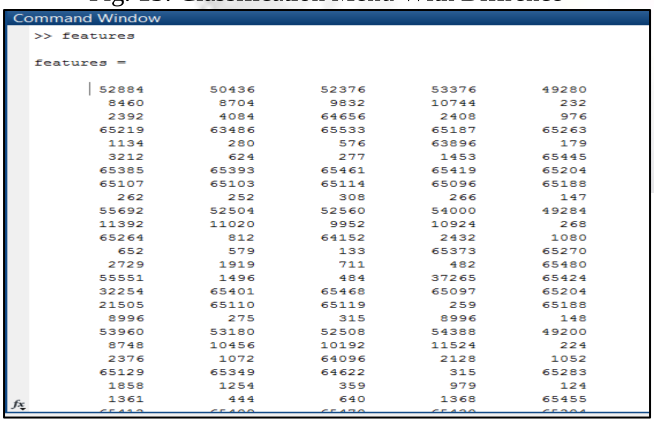


Fig. 14: Features of Evaluated Data

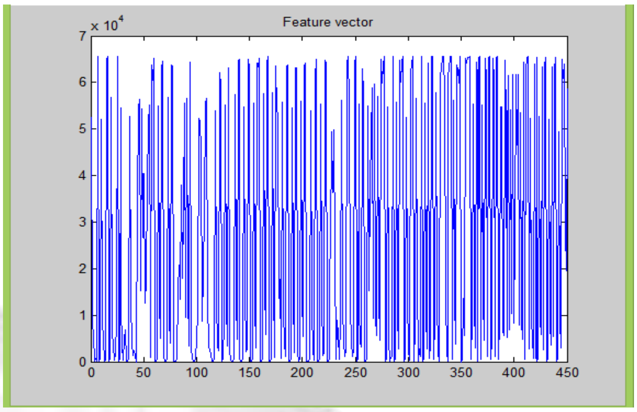


Fig. 15: Feature Vector Graph

IV. Result and Conclusion

Several experiment have been performed and our device was validated for the following experiment

- Signature
- English alphabet
- English sentences

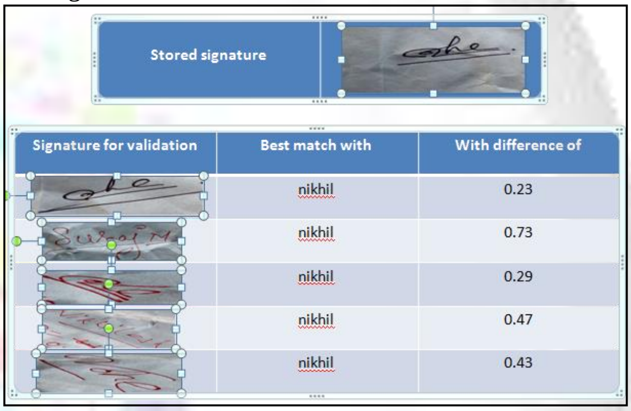


Fig. 16: Result of Signature Evaluation

The accuracy for different experiment was based on the validation table drawn on the basis of number of random experiment performed for different writing style by different persons and we observed the following validation.

Minimum Difference	Case
0	IDEAL
0-0.3	VALIDATE
0.3<	NOT VALIDATE

Fig. 17: Validation Table

And it was observed that accuracy for all the above mentioned validation for 20 numbers of samples has given us the following reading.

Validity	Accuracy
English alphabet	Approx 92%
Signature	Approx 96%
Sentences	Approx 94%

Fig. 18: Accuracy Table

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