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Accelerometer Based Device for Handwritten Digit and Gesture Recognition

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Abstract: **- This paper presents an accelerometer-based device for handwritten digit and gesture trajectory recognition. The accelerometer based device consists of basically three main parts i.e triaxial accelerometer, microcontroller and RF wireless transmission module.This parts used for sensing and collecting accelerations of handwriting and gesture trajectories of hand motions.The minimised features are passed to a neural network for recognition.The main important experimental results have successfully validated the effectiveness of the trajectory recogni-tion algorithm for the proposed device.**

***Index Terms*— Micro-Electro-Mechanical Sys-tems,Interquartile range,Root mean Square, Probabilistic neural network,linear discriminant analysis),Kernel-based class separability.**

I. INTRODUCTION

The growth of different technologies in electronic circuits in daily human life and electronic components has fastly decreased the dimension and weight of custumer electronic products, such as smart phones and handheld computers, and thus made them more usable and convenient.A useful best advantage of inertial sensors for different hand motions of material sensing is that they can be operated without any outside reference and developed in working conditions.Hence, different scientists have tried to resolve the problem domain for increasing the accuracy of handwriting digits and gesture recognition systems.At this time, some scientists have con-centrated on minimizing the problems of handwriting digits trajectory reconstruction by manipulating acceleration signals of the hand motions and angular velocities of inertial sensors of that signals.Many different scientists try to focus on devel-oping effective algorithms for error compensation of inertial sensors of that signals to increase the recognition accuracy of that acceleration signals.[4][6][8][11][15].

II. HARDWARE DESIGN OF DEVICE

The device used in accelerometer based device consists of three main parts 1) A triaxial accelerometer (LIS3L02AQ3),2) A microcontroller (C8051F206) and 3) A wireless transceiver shown in figure 1 The accelerometer counts the acceleration signals generated by hand motions. The atmega 16 microcontroller handles and collect the analog acceleration signals of hand motions and by using analog to digital converter converts the different

Fig. 1. Block diagram of Device [4]

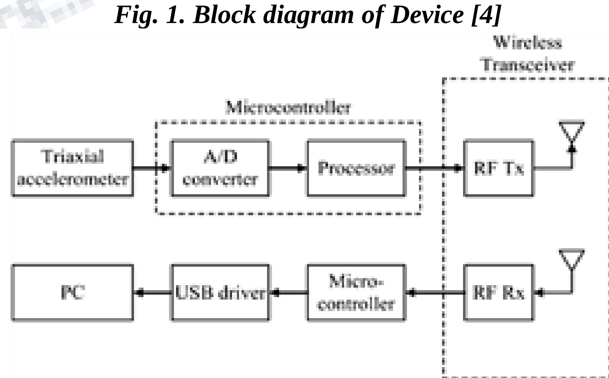

Fig. 2. Schematic diagram of the module [5]

acceleration analog signals to digital signals. The wireless transceiver transferred the acceleration signals to a PC. The ADXL335 is a low-cost accelerometer having a tem-perature compensation function,a g-select function. The ac-celerometers sensitivity is fixed for this work from -3g to +3 g . The LPC2148 integrates to increase the performance 12-bit analog to digital(A/D) converter and after completing optimise signal cycle 25-MHz 32-bit microcontroller unit on a signal chip.The accelerometer are sampled at 100 Hz by the 12-bit analog to digital(A/D) converter output signals.then all the acceleration signals sensed by the accelerometer are transmitted wirelessly to a PC by an RF transceiver at 2.4-GHz with 1-Mb/s transmission rate. The total power utilization or consumption of the device circuit is range of 30 mA at 3.6 V. part, we neglect KBCS to select exact useful different features after that use LDA to minimize the dimensions of the different features.

III. TRAJECTORY RECOGNITION ALGORITHM

The block diagram of the trajectory recognition algorithm consisting of five different blocks first is acceleration acq uisi-tion, second is signal preprocessing, third is feature generation, fourth is feature selection, and fifth is feature extraction is shown in Figure

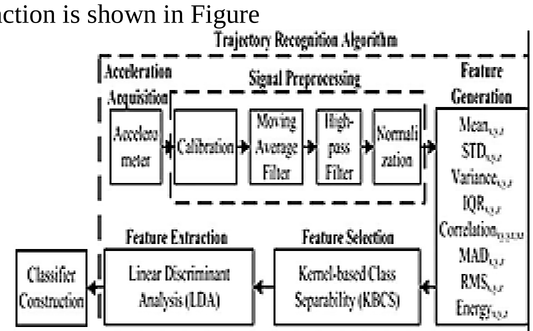

Fig. 3. Block diagram. [4]

The signals of the hand motions are measured by a ac-celerometer and then preprocessed by filtering and normaliz a-tion.The minimized feature vectors are fed into a the classifier to recognize the different motions to which the feature vector belongs. The step wise procedure of the five different trajec tory recognition algorithms of the different acceleration signals are as follows.[4]

A. Signal Preprocessing

The different acceleration signals i.e.different motions of the hand are generated through the accelerometer and cap-tured or collected by the microcontroller.Because of weakness of the hand always trembles slightly while different hand motions, which creates certain amount of noise. The signal preprocessing of the acceleration signals block consists of the four different processes i.e. first -calibration, second-a moving average filter, third-a high-pass filter and fourth-normali zation.

B. Feature Generation

The different characteristics of hand movement accel-eration signals of the hand can be obtained by dif-Ferent extracting features from the preprocessed three Axis signals out of that extract different eight features From the triaxial acceleration signals of hand motions viz. 1.Mean,2.STD,3.VAR,4.IQR,5.correlation between axes ,6.MAD,7.rms,and 8.Energy. When this generation procedure is completed, 24 different features are then obtained. Because the large amount of the extracted features is having long procedure to completes this part, we neglect KBCS to select exact useful different features after that use LDA to minimize the dimensions of the different features.

C. Feature Selection

The scientist Wang originally developed the adopted selec-tion criteria of the different features in the KBCS.

D. Feature Extraction

The main purpose of Linear discriminant analysis is to divide the data distribution in different parts and minimize the data distribution of the same class in a new space. After completing the feature extraction, these minimized features will be fed into the classifier device to recognize different hand movements.

E. Classifier Construction

The classifier first used to training data, the it is guarantee d to converge to a Bayesian classifier. The clasifier consists of an four different layers shown in Figure

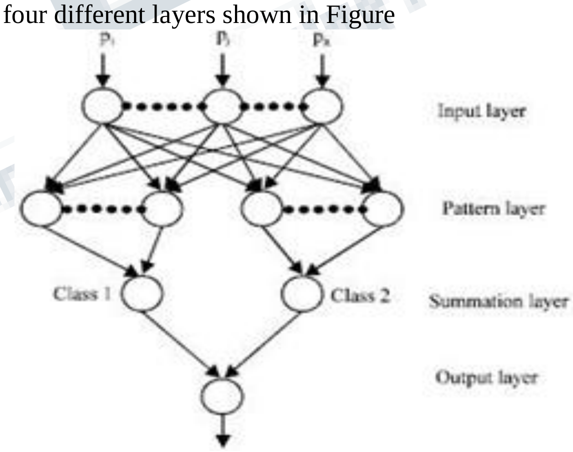

Fig. 4. Topology of a PNN classifier.[6]

• First layer: The first layer is the input layer, this per-formed on the basis of no computation. The different neurons in the first layer is used to communicate with the input different features x to the selected different neurons of the second layer directly

$$X = [X1, X2, ...Xp]^T \qquad (1)$$

where p-is the total number of the extracted features of the different signals.

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• Second Layer : It contains number of neurons in this layer is equal to NL

$$\phi_{ki}(x) = \frac{1}{(2\pi)^{d\backslash 2}\sigma^{d}} \mathrm{EXP}\left(-\frac{(x - x_{ki})^{T}(x - x_{ki})}{2\sigma^{2}}\right) \quad (2)$$

where xki is the neuron vector, σ is a smoothing param-eter, d is the dimension of the pattern vector x, and ϕki is the output of the pattern layer.

• Third Layer: The third layer in the classifier construction is the summation layer.

The output of the kth neuron is

$$p_k(x) = \frac{1}{(2\pi)^{d\backslash 2}\sigma^{d}}\frac{1}{N_i} \mathrm{EXP}\left(-\frac{(x - x_{ki})^{T}(x - x_{ki})}{2\sigma^{2}}\right) \quad (3)$$

where Ni is the total number of samples in the kth neuron.

• Fourth Layer: This is the output layer.

$$c(X) = \mathrm{ARG\,MAX}\ p_k(X),\ k = 1, 2, \ldots\ldots m \quad (4)$$

The output of the classifier is represented as the label of the desired outcome defined.

IV. EXPERIMENTAL RERULT

The effectiveness of trajectory recognition algorithm in the device is validated by the following two experiments or two recognition parts.

A. Handwritten digit recognition

The paralyzed patient hold the device to draw the trajecto-ries of Arabic numerals or the digits and the device tip must touch a table. The acceleration signals of the hand motions of the paralyzed patient after the signal preprocessing procedure of the proposed trajectory recognition algorithm for the digit 0 are shown in Figure. The recognized acceleration signals acquired from accelerometer module in device are shown in Figure.The acceleration signals the hand motions were filte red via the moving average filter to minimize the high-frequency noise.At the end the gravitational acceleration was eliminated from the filtered acceleration signals via a high-pass filter to obtain the accelerations signals caused by hand movement.

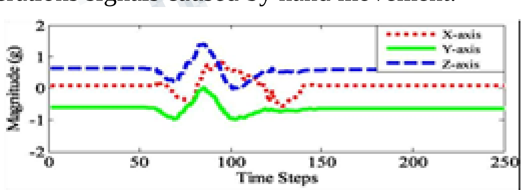

Fig. 5. Calibrated accelerations of digit 0[5]

With the preprocessed accelerations signals of the different hand motions of the paralyzed patient, generally 24 different features are generated by using the feature generation proce-dure.

We select digits 0 and 6 to illustrate the effectiveness of the Kernel-based class separability, since their accelerations and handwritten trajectories of the paralyzed patient are pretty similar and difficult to classify. The Interquartile range of the features of these two digits are closely overlapped

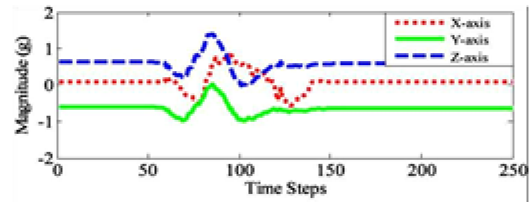

Fig. 6. Filtered accelerations by a moving average filter of d igit 0[5]

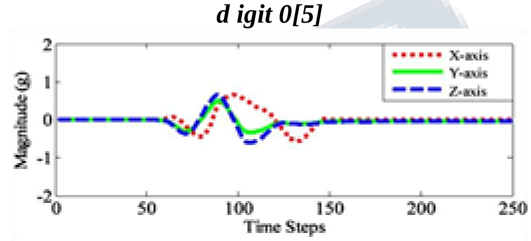

Fig. 7. Filtered accelerations by a HPF of digit 0[5]

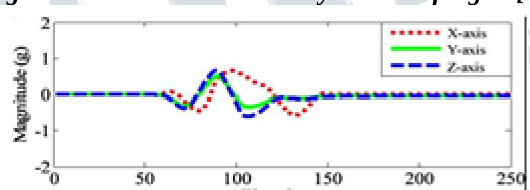

Fig. 8. Preprocessed acceleration of digit 0[5]

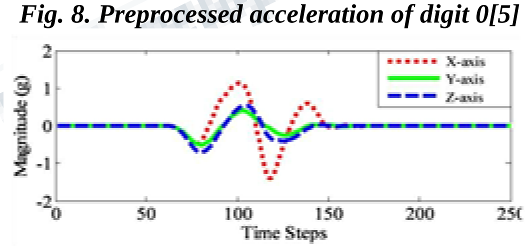

Fig. 9. Preprocessed acceleration of digit 6[5]

The digits can be well separated by the mean features according to their vector cluster distributions. If computational burden for feature selection criteria is concerned, these can be excluded from the candidate features of the different features. At the end there we having 11 significant different features including corrxz, meanx, meany, MADx, IQRx, rmsx, corrxy , mean, energyx, energyy, energyz selected from 24 different features by the Kernel-based class separability. After classified the ten needed digits, the maximum of the dimension of the feature extraction by the Linear discriminant analysis was 9. To see the performance variation or fluctu-ations caused by different feature dimensions, we varied the

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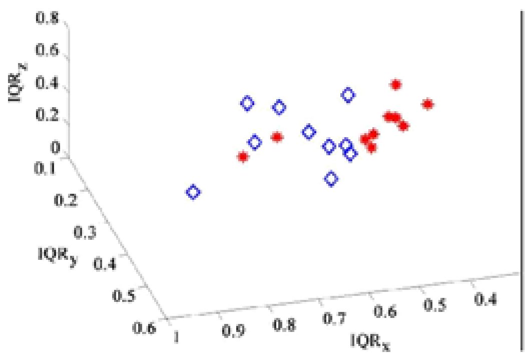

Fig. 10. Interquartile range features of digit 0 and digit 6[6]

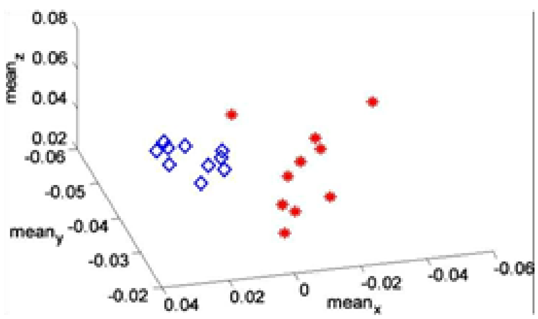

Fig. 11. Interquartile range features of digit 0 and digit 6[6]

dimensions of the different feature of the Linear discriminant analysis from one to nine. The best average recognition rate of the classifier was 97 % when the feature dimension was set to nine by using the Linear discriminant analysis. The procedure used to evaluate the recognition performance rate of the KBCS is the same as that of the Linear discriminant analysis.The best feature recognition rate was 82 % when the feature dimension was set to 11, and there was no further improvement for larger numbers of dimensions.

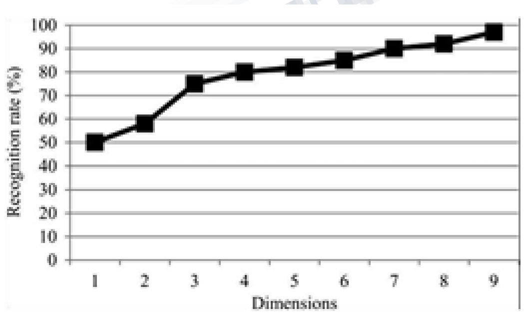

Fig. 12. Comparison of Average recognition rates and feature dimentions of the classifier by using the LDA.[6]

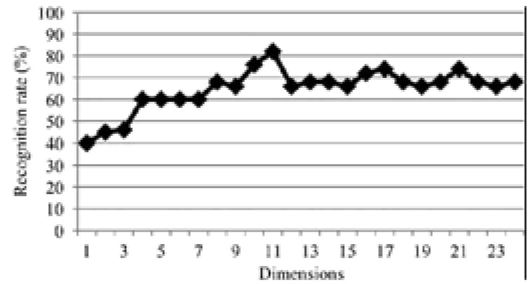

Fig. 13. Comparison of Average recognition rates and feature dimentions of the classifier by using the KBCS.[6]

B. Gesture Recognition

In this method hold the pen to perform eight hand gestures in a 3-D space. The different gestures are shown in below

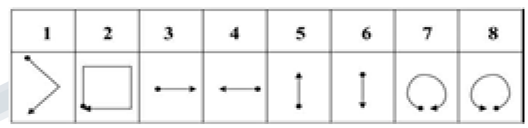

Fig. 14. Trajectories of different eight hand gestures[4]

Table exhibits the average recognition rates of the PNN and FNN classifiers using the addition of KBCS and Linear discriminant analysis for the feature selection and extraction methods.The Linear discriminant analysis further minimized the feature dimension 24 to 12 to 7.

classifier	Recognition rate(%)
PNN	98.75
FNN	96.25

Table I Trajectories of eight hand gestures

This paper includes the different fea- turesof 12 significant features including meanx, corrxz, corry z, meanz, meany, MADz , MADy, IQRz , IQRx, MADx, rmsz , and rmsx were selected by the KBCS. From the above mentioned two methods, the proposed recognition algorithm can effectively recognize different hand trajectories that can be defined as various different commands for human computer interaction viz. game controller, TV remote control, and presentation pointer with motion recognition capability.

V. CONCLUSION

In The Accelerometer based Device for Handwritten Digit and Gesture Recognition the trajectory recognition algorithm consists of acceleration acquisition, signal preprocessing, fea-ture generation, feature selection, and feature extraction.In the research paper, we used 2-D handwriting digits and 3-D hand gestures to validate the effectiveness of the device and

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algorithm.The overall or total handwritten digit recognition

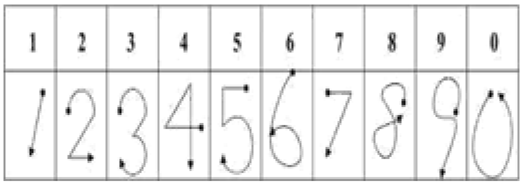

Fig. 15. Different numbers used as digits[5]

rate was 98%, and the gesture recognition rate was also having stable 98.75%.

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