A Review Paper on Human Activity Recognition Using Smart Phone Sensors

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Abstract- As there is rapid development in computer technology; the interaction between human and computer is become a topic of research, where we can use mobile devices for data mining applications as mobile devices are user friendly and incorporates with many powerful sensors. These sensors include acceleration sensors, vision sensors, audio sensors, light sensors, temperature sensors, direction sensors, and GPS sensors. In this paper we describe the uses of android mobile accelerometers and computer for gestures recognition for hand written digit and survey of recent hand gesture recognition systems is presented. Key issues of hand gesture recognition system are presented with challenges of gesture system. Also review methods of recent gestures recognition system are presented.

Index-terms - Hand Gesture, GPS, Human Computer Interaction (HCI).

I. INTRODUCTION

The main aim of building hand gesture recognition system is to create an interaction between human being and computer where the recognized gestures can be used for conveying meaningful information. Day by day Percentage of disabled persons in India is increasing both in rural and urban areas. As writing is a challenging task for physically disable people, old age people and paralyzed patient. So our project works as a device which is use to recognized gesture recognition of hand written digit so that disable, old age, paralyzed people can convey meaningful message by only doing some gesture. Different methods have been proposed for acquiring information necessary for gestures recognition system. Some methods used additional hardware devices such as MEMS accelerometer sensor, RF transmitter receiver, microcontroller, data glove devices and color markers to extract gesture features. Other methods based on the appearance of the hand using the skin color to segment the hand and extract necessary features. Our methods considered easy and less cost comparing with methods mentioned above. Some reviews explained gesture recognition system applications and its growing importance in our life especially for Human computer Interaction HCI, Robot control, games, and surveillance using different tools and algorithms. In this work we demonstrate the advancement of the gesture recognition systems, with the discussion of different stages required to build a complete system with good accuracy and with low cost using different algorithms.

There are several survey works on gesture recognition using different ways which are explained in literature review. In this paper we aim to summarize the recent advances of gesture recognition with mobile sensors. The proposed gesture recognition methods can be split into five main phases which contains signal acquisition, signal preprocessing, features extraction, feature selection and recognition finally conclusion.

II. LITERATURE REVIEW

This chapter describes brief about literature survey, the field of gesture recognition has been extensively studied in the past. Recently, some studies have focused on the development of accelerometer based digital pens for gesture recognition of hand written digit.

Jeen- ShingWang and Fang-Chen Chuang [1] presented a technique which is based on accelerometer-based digital pen for handwritten digit and gesture trajectory recognition. The digital pen consists of a tri-axial accelerometer, a microcontroller, and an RF 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. 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. The algorithm first extracts the time- and frequency-domain features from the acceleration signals and then further identifies the most important features by hybrid method kernel-based class separability for selecting significant features and linear discriminate analysis (LDA) for reducing the dimension of features. The reduced features are sent to a trained probabilistic neural network for recognition.

Jennifer R. Kwapisz, Gary M. Weiss, Samuel A. Moore [2] describes and evaluates a system that uses phone-based accelerometers to perform activity recognition, a task which involves identifying the physical activity of a user. To implement this system they collect

labeled accelerometer data from twenty-nine users as they performed daily activities such as walking, jogging, climbing stairs, sitting, and standing, and then aggregated this time series data into examples that summarize the user activity over 10- second intervals. Then this data is used as the resulting training data to induce a predictive model for activity recognition. This work is significant because the activity recognition model permits to gain useful knowledge about the habits of millions of users passively just by having they carry cell phones in their pockets.

Jeen-Shing Wang Yu-Liang Hsu Cheng-Ling Chu [3] presents an accelerometer-based pen device for online handwriting recognition applications. The accelerometer-based pen device consists of a tri-axial accelerometer, a microcontroller, and an RF wireless transmission module. Users can hold the pen device to write numerals in air without space limitations. The accelerations generated by hand motions are generated by the accelerometer embedded in the pen device, and are transmitted to a personal computer for further signal preprocess via the wireless module. Subsequently, 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 can be recognized via the alignment with the class templates in the testing stage.

Jeen-Shing Wang, Yu-Liang Hsu, and Jiun-Nan Liu [4] presented a technique which describes an inertial-measurement unit-based pen (IMUPEN) and its associated trajectory reconstruction algorithm for motion trajectory reconstruction and handwritten digit recognition applications. The IMUPEN is compose of a tri-axial accelerometer, two gyroscopes, a micro controller, and an RF wireless transmission module. Users can hold the IMUPEN to write numerals or draw simple symbols at normal speed. During writing or drawing movements, the inertial signals generated for the movements are transmitted to a computer via the wireless module where signals are processed and recognized.

Renqiang Xie, and Juncheng Cao [5] which describes an accelerometer-based pen-type sensing device and a user-independent hand gesture recognition algorithm. Users can hold the device to perform hand gestures with their preferred hand held styles. Gestures in our system are divided into two types the basic gesture and the complex gesture which can be represented as a basic gesture sequence. A dictionary of 24 gestures including 8 basic gestures and 16 complex gestures is defined. An effective segmentation algorithm is developed to identify individual basic gesture motion intervals automatically. Through segmentation, each complex gesture is segmented into several basic gestures. Based on the kinematics characteristics of the basic gesture, 24 features are extracted to train the feed forward neural network model. For basic gesture recognition, the input gestures are classified directly by the feed forward neural network classifier

Michael Xie and David Pan [6] which describes paper, in which there is development of a highly accurate SVM classifier using only 1 training example per class. This algorithm, during preprocessing improved accuracy on 1 training example per class by 14% and the addition of axis-wise Discrete Fourier Transform coefficient features improved accuracy on 1 training example per class by 5%. With 5 gesture classes, 1 training example for each class, and 30 test examples for each class, our classifier achieves 96% accuracy. With 5 training examples per class, the classifier achieves 98% accuracy, which is greater than the 10-example accuracy of other efforts using HMM's. This makes it feasible for a real-time implementation of accelerometer-based gesture recognition to identify user-defend gestures with high accuracy while requiring little training effort from the user.

Smitha K.S [7] proposed a technique of activity recognition module includes five main steps. Create an application on the android phone, data collection, segmentation, feature extraction, classification. For create an application, users build and develop their applications. In data collection, the raw data for walking, running and stand idle are collected separately by activating the application on the phone and place it on shirt's pocket or on trouser's pocket. Raw data is collected for every 20 seconds interval. For feature extraction a buffer register is initialized for saving the collected data. First the buffer will be initialized with zero values for x axis, Y axis and z axis values. The data is stored as array. For creating the data set it can be possible to extract both time domain features and frequency domain features. The time domain features include mean, standard deviation, maximum value and minimum value. Frequency domain features can be computed from the FFT analysis of the data. In classification, activities like standing, walking and running, continuously observe each activity so many times and set a threshold frequency value corresponding to maximum amplitude level for activities. In training stage, the frequency point corresponding to maximum amplitude is compared with the threshold value and fixes the activity. During testing stage, the activity will be classified accurately.

III. PROPOSED WORK

As per discussed above methods of gesture recognition, to capture acceleration signals generated by hand motion of different gestures, requires various different hardware like MEMS accelerometer based digital PEN or hand gloves. Acquisition of signals required RF transmitter and receiver module which increases the cost of project. Our paper represent a technique with zero cost by simply using android mobile which is capable of both sensing and transmitting the signal. Further processing is as follows.

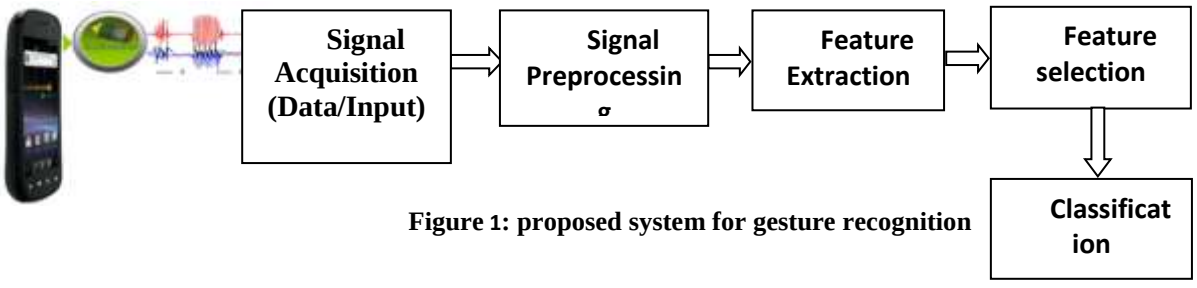

Figure 1: proposed system for gesture recognition

Input Signal acquisition

MEMS accelerometers in mobile phone are capable of detecting the orientation of the device which can provide useful information for trajectories recognition. Sensors have been proposed to sense or capture acceleration signals generated by writing trajectories. Acceleration signal generated by mobile phone are transmitted to computer by using suitable interface.

Signal Preprocessing

The raw acceleration signals contain noise because our hand always trembles slightly while moving. Also noise is added due to gravitational field, to remove these noise signal preprocessing is required which 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 signal then we utilize a high-pass filter to remove the gravitational acceleration from the filtered acceleration to obtain accelerations caused by hand movements. In general, the size of samples of each movement between fast and slow writers is different. Therefore, after filtering the data, we first segment each movement signal properly to extract the exact motion interval. Then we normalize each segmented motion interval into equal sizes using interpolation. Once the preprocessing procedure is completed, the features can be extracted from the preprocessed acceleration signals.

Feature Extraction

In activity recognition algorithm we extract features form acceleration signal generated by hand motion. Extracted features are from both domain time and frequency domains. Some features are from time domain and some are from frequency domain

Time-domain features

1. *Mean:*

   The mean feature represents value of each segment in each dimension.
2. *Max, Min:*

   The maximum and minimum feature represents values of each segment in each dimension.
3. *Variance /(STD)Standard deviation:*

   It measures how far a data set is spread out.
4. *Correlation:*

   Correlation is calculated between each pair of axes of the acceleration data.

Frequency-domain features

Frequency-domain features describe the periodicity of the signal, which are typically calculated based on the FFT.

1. *Energy*

   The energy feature is calculated as the sum of the squared discrete FFT component magnitudes.
2. *Entropy*

The entropy feature is calculated as the normalized information entropy of the discrete FFT components, and it helps in discriminating the activities with the similar energy features. After the procedure of feature extraction is done. We use KBCS (Kernel-based class separability) to select most useful features and then use LDA (Linear Discriminate Analysis) to reduce the dimensions of features.

Feature selection

In this process we select the features which are informative and non redundant, facilitating the subsequent learning and generalization steps, and in some cases leading to better human interpretations. Feature selection is used to reduce the dimension of feature vector.

After feature extraction, we got some dimensional feature vector. To increase the rate of processing and compress data, it is necessary to reduce the dimension of feature vector. Furthermore, not all these features we extracted is ``good" enough, and the ``no good" features should be eliminated. Here we perform feature analysis and select the effective features to speed up the computation as well as reduce the memory used.

Classifier

Gesture classification method is used to recognize the gesture. Recognition process affected with the proper selection of features parameters and suitable classification algorithm. Classifier classifies the testing signals feature values and feature data base values and give the output. Generally, there were two main learning strategies in classifiers supervised and unsupervised learning. In the supervised learning, classifiers train only labeled data but training the unlabeled data is difficult, expensive, and time consuming because it needs human knowledge and ability. One the other hand, in the unsupervised learning, there is no supervisor to learn classifiers to label the data. In this strategy, classifier work with only unlabeled data and classify them according to some similar features they have. In the semi-supervised learning method, it has been found that unlabeled data when used in conjunction with a small amount of labeled data can produce considerable improvement in learning accuracy. In Self-Training, classification process is done in two stages. First, the classifier is trained by known data and then it uses to predict the labels of unlabeled data. The unlabeled data with high confident scores adds to the training set with estimated labels, and then this process repeats until the convergence.

In this paper, we present another version of the Help-Training strategy i.e. Probabilistic Neural Network. After the classification is done by PNN classifier signal are compared with the stored feature of gesture if any match found with stored feature data it shows the respective digit

IV. CONCLUSION

Gesture recognition is helpful in interaction between computer and human being and also in sign language recognition which is highly demanding application now days. In this paper various methods are discussed for gesture recognition by different authors which includes accelerometer based digital pen like device, hand glove based gesture recognition technique as these techniques are suffer from various conditions like additional hardware which includes transmitter, receiver hand glove like devices which makes it costly. As our method is cost effective comparing with above methods. We use suitable classifier to increase accuracy of gesture recognition. Explanation of gesture recognition issues, detail discussion of recent recognition systems are given as well. Summary of some selected systems are listed as well.

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