Survey on Soft Computing Approaches for Human Activity Recognition

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Abstract: *Human activity recognition is intrinsic area of exploration just because of its real world's applications. The sensors included smart phones are used to recognize activity. Mobile phone provides small size, CPU, Memory and Battery. A detailed survey of Design classifier for human activity recognition systems by using soft computing techniques are discussed in this report. Also various classifiers are discussing in this survey. Describe supervised and unsupervised learning. Also describe various types of classifiers in this paper.*

Keywords: HAR; Classification; clustering; Machine learning

1. Introduction

Human activity recognition (HAR) apprehends the regard of various computer science communities just because of its potency in real world application. Human activity recognition is done over the sensor based system. The scrutiny of big quantities of the data that are placed in computers done by using data mining. There are several distinct objective of data mining mainly categorized as classification, clustering, feature selection association rule mining.

Classification is nothing but method of building a model of classes by using group of records that comprise class labels. The organization of data in given class is called classification analysis. Also called as supervised classification, the classification method uses class label which are given to order the objects in data collection steps. Normally training set is used by classification approaches where all objects are belongs to the class label which is known. To building a model classification algorithm needs to learning from the training set. New objects are classified by using the model.

Soft computing refers to the science of reasoning, thinking and deduction that organizes and uses the real world phenomena of grouping, memberships and classification of various quantities under study [1]. As such, it is an extension of natural heuristics and capable of dealing with complex system because it does not require strict mathematical definitions and distinction for the system component.

Traditionally soft computing approach to be composed of some technical protocols such as neural network, fuzzy logic and support vector machine (SVM).Human activity recognition used classifier that is SVM which is well known classifier and also provides an accurate results with respect to other. A detailed survey of soft computing approach for human activity recognition systems are discussed in this report. Also various classifiers are discussing in this survey. Describe supervised and unsupervised learning.

A. About HAR (Human Activity Recognition)

There are novel applications by using HAR. Initially Wearable sensors were used for the detection of HAR system. Nowadays there were tremendous growth in the development and providing advanced features in mobile device along with its sensors such as accelerometer to magnetometer. These HAR systems are use for military system, healthcare, intelligent homes, security etc. There are two way to recognize activity online and offline activity recognition. Sensor data has collected on mobile phones by using machine learning tool. Various studies covered up human activity recognition tools are developed on mobile devices for real world process. These collections of data, preprocessing, classification steps are conducted by using smart phone or mobile device. Initially mobile devices were consider as resource limited devices but nowadays advance Smart phones containing more features such as provide more battery backups. Recognition of activity to be composed of further steps namely data collection by using sensor hence called sensing, preprocessing, feature extraction and classification. Figure 1will gives the correct idea about the process steps. The sensing phase contains data collected on sensor. Preprocessing consist of removing noise and windowing data. Feature extraction consists of data classification. Classifier should be used to training and testing purpose. Classification is important step for training data. [2]

Mobile sensors provide the novel characteristics such as small size, CPU, memory and flexibility to conducting activity. There are two types of wearable sensors external and wearable sensor. Intelligent homes are the example of external sensor. Also these sensors used an external camera that works like image processing. Activity such as walking, running, bicycling are conduct in healthcare human activity system. That will give the correct idea about patient health to the caretaker. Accelerometer is used to recognize the motion such as walking, running activity.GPS global position sensor used to recognize position such as location of the subject.

Also environmental sensor used to recognized temperature, humidity, audio sequence of the subject. [3]

Human activity recognition has novel application in Ambient Intelligent system that can be used to make smart environment such as Microsoft kinect offices in universities to make smart environment. These systems working like human mind.
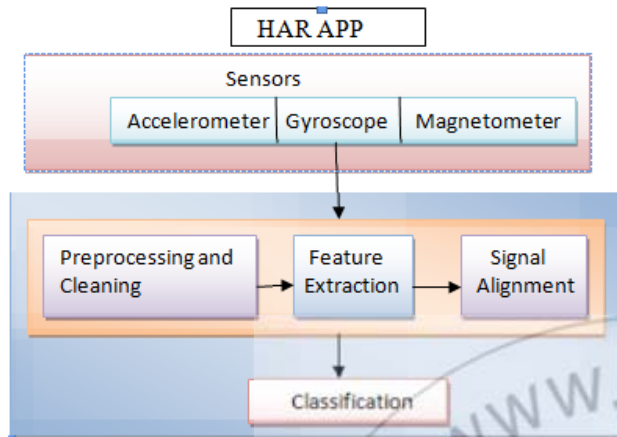

Figure 1: The Process Diagram

Various classifiers are used to training and testing purpose of the data.SVM is important classifier that has been use to give accurate result. Wireless sensors and actuator network are used to determine temperature, humidity and light works same as environmental sensor. [4]

Human motion analysis is very vast topic in the research area. In this activity recognition task such as complicated task gesture detection will require more efforts. Depth of the system will used to recognize gesture and posture of the system. Complex activity such as watching movie in the theater will not give accurate result. No researcher has able to conduct that kind of complex activity. Also "fall" detection is included in complex activity that system will not give robustness. [5]

Computer vision based techniques can be used to tracking activity but infrastructure support will be required such as installation cameras in monitoring area. Hence sensor based techniques are used to tracking activity just because of small size, memory and CPU. Mobile phones providing portability and easily can be performed activity. Accelerometer includes the data on acceleration over x axis, y axis and z axis. Feature evaluation step containing classifier should be developed. Feature creation is critical stage. SVM, Multilayer Perceptron, Decision tree, Random Forest, Logic Boost that can be trained and tested by using 10 fold cross validation to receiving proper results. [6]

Human activity recognition has huge demand as life logging. Convolutional neural network can capture signals local dependency and scale variant as image processing. In image processing task pixel has strong relationship with each other. Scale is variant in image recognition task for scale variant method. Feature extraction is important step in activity recognition. The statical features mean, deviation can be used

as hand crafted features. Fast furrier transform and wavelet transform are included in hand crafted features. [7]

Activity recognition can be appliance in combination with pattern matching feature because transformation in the routine of subject. The activity recognition can be track using environmental and network sensors. Environmental sensor tracking location, motion and wearable sensors attached to the body track acceleration of limbs. Simple activity can be tracking easily but the complex activity is not easy to determine. Activity such as falling, cooking, cleaning etc. [8]

Human activity recognition can be divided into two groups sensor based and vision based. Sensor based technique can be used to recognize asction can be monitor. Vision based technique used a wearable sensor attached to the body that required to image detection, image processing and video sequence external cameras attached to it. Sensor based system requires a classification algorithm that are as speedy as wearable sensor. [9]

Smart phone which included embedded sensor Accelerometer can be used to classify activities such as running, walking, stair up and stair down. Accelerometer includes the acceleration information determine the user behavior. [10]

There are several sensors available in smart phone that make more opportunities in mass marketed communication provide huge scope to data mining and data mining applications. The several classifiers are used to testing and training purpose of data. There were tremendous growths in mobile smart phone devices that provide Android operating system. A maximum researcher includes Android as platform for the activity recognition. Android provide free open source operating system for mobile device. Tri-axial accelerometer used to recognize activity along with x; y and z axis from velocity to displacement can be estimated. Accelerometer can be used as motion detector. KNN is one of the most popular algorithm for pattern matching. This algorithm can be used to classify net data object that from attributes samples and training samples. [11]

Classification of human activity recognition has big challenges just because of its high dimension data; training data acquisition difficulties in characteristics require classification speed, good effects generalization ability characteristics. [12]

For HAR mean, entropy and standard deviation of accelerometer computed over time window can be viewed as the machine learning features. The first step in HAR is to collecting data from accelerometer sensors data with noise. After collecting data noise should be removed then windowing phase has been conducting. After this features extraction has been done mean, max, FFT, entropy, standard deviation all features has conducting. Row data is used to conduct training and testing purpose of the classifier. [13]

Testing phase is carried out by using 10 fold cross validation method. That will give correct features results time domain, vertical and horizontal features. [14]

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Recognition of activity can be done into three main steps data collection, features extraction and classification training and testing. The whole process will extract the features from data collected. [15]

In human action recognition the researcher should have the common sense knowledge and reasoning ability. That recognition task is work on the basis of video sequence. [16]

In HAR multi level activity classes can be observed as different activity e.g. cooking can be divided into two parts cutting and boiling. [17]

The parameters of the classifier are detected using supervised datasets and cross validation. [18]

Automatic physical activity recognition will helps people live fit .The real world algorithm give more efficiency to the people improvement in their health and heart rate monitor system. [19]

Typically classifier was trained from the data collected from the large number of activity running, walking and sitting. Accelerometer is very effectively detecting accurate activity. [20]

There were tremendous growths in wireless and wired network. Nowadays that has been shifted towards wired to wireless network that are easily available. To design and implement mobile application framework which is capable of supporting various heterogeneous environment called ART. [21]

The GPS system is very efficient when GPS signals are available. [22]

Smartphone achieved good classification accuracy. Smart watches also can be used sport tracking application. The algorithms are used to save the battery power. [23]

Portable sensors are either wearable on smart phone based platform. [24]

Multitask learning is very expensive for computation, it is important to speed up training with online algorithm. Structure classification method is used for continuous activity recognition. [25]

B. Classification
Supervised learning algorithm includes classification and unsupervised learning includes clustering.

1) Unsupervised
Accumulation of data object is nothing but cluster – In the same cluster that is akin to one another – Distinct with the objects in another cluster .Unsupervised learning is the machine learning task of ascertain activity to characterize unseen anatomy from unlabeled data. In data analysis the initial and fundamental step is clustering. Among neural network models, the self organization map (SOM) and adaptive resonance theory (ART) are commonly used unsupervised learning algorithms. The SOM is a topographic

organization in which nearby locations in the map represent inputs with similar properties .It is an unsupervised classification of patterns into groups or we can say clusters. Intuitively, patterns within a valid cluster are more similar to each other and dissimilar when [26] compared to a pattern belonging to other cluster. Clustering is useful in several fields such as pattern analysis, machine learning situation also pattern classification and many other fields. Clustering is the task of assigning a set of objects into groups (called clusters) so that the objects in the same cluster are more similar (in some sense or another) to each other than to those in other clusters. Clustering is a main task of explorative data mining, and a common technique for statistical data analysis used in many fields, including machine learning, pattern recognition, image analysis, information retrieval, and bioinformatics. In data mining, k-means clustering [27] is a method of cluster analysis which aims to partition n observations into k clusters in which each observation belongs to the cluster with the nearest mean [28].This results into a partitioning of the data space into Verona cells. K-means (Macqueen, 1967) is one of the simplest unsupervised learning algorithms that solve the well known clustering problem. Disadvantages to Using this Technique

- Difficulty in comparing quality of the clusters produced (e.g. for different initial partitions or values of K affect outcome).
- Fixed number of clusters can make it difficult to predict what K should be.
- Does not work well with non-globular clusters. Different initial partitions can result in different final clusters. It is helpful to rerun the program using the same as well as different K values, to compare the results achieved.

2) Supervised:
Classification – Predicts categorical class labels – Classifies data (constructs a model) based on a training set and the values (class labels) in a class label attribute – Uses the model in classifying new data. Supervised learning is the machine learning task of inferring a function from labeled training data. Classification is process of grouping together documents or data that have similar properties or are related. Our understanding of the data and documents become greater and easier once they are classified. We can also infer logic based on the classification. Most of all it makes the new data to be sorted easily and retrieval faster with better results. The Term classifier applies always to a classifier trained for the distinction between two classes, the presence or absence [29].

2. Different Types of Classifier

a) Decision Tree Algorithm J48
For classification the J48 classifier is a simple C4.5 decision tree. That can make a binary tree. These decision tree method of classification is helpful for solving the problem of classification. By using this skill a tree is built to model the classification process. Once the tree is constructing, it can applied to each and every tuple in the database and results in classification for that tuple. [30] Decision tree is exclusively approach which makes multistage decision. It containing

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root, node and leaf. It is used as data mining tool because making decision hierarchically. [31]

b) Naïve Bayes classifier:

The simple probabilistic classifier is a Naive Bayes classification algorithm which can compute a set of probabilities by calculating the frequency and combinations of values in a given data set. In this classification algorithm that usage Bayes theorem and postulate all attributes to be independent given the value of the class variable. This conditional independence assumption rarely holds true in real world applications, hence the characterization as Naive yet the algorithm tends to perform well and learn rapidly in various supervised classification Problems [32].

c) SVM (Support Vector Machine)

These are supervised learning methods which can utilize for classification in support vector machines. Also SVM use for regression. The theory of the support vector machine (SVM) is advanced by Vapnic (1995,1998)[33].The benefit of Support Vector Machines is that can making usage of certain kernels in order to transform the problem, such that can apply linear classification techniques to non-linear data. Applying the kernel equations arranges the data instances in such a way within the multi-dimensional space, that there is a hyper-plane that separates data instances of one kind from those of another.

The kernel equations may be any function that transforms the linearly non-separable data in one domain into another domain where the instances become linearly separable. Kernel equations may be linear, quadratic, Gaussian, or anything else that achieves this particular purpose.

SVM is able to achieve high accuracy .it is scale with data dimensionality; it is simple form and hence execute fast runtime. It is one of the best classifier that has been successfully applied in activity recognition. The classification sampling rate is depends on feature set, upon which classifier is built [34]. SVM was originally designed for binary classification. It cannot deal multiclass classification directly [35].

d) KNN

KNN is nonparametric algorithm that working on practical real world application not going through theoretical based. This method of classifications consider as lazy learning algorithm as it doesn't required training time of computation. This classifier is well known for its simplicity, speed and good classification result. [36]

e) Random Forest

The random forest machine learner, is a meta-learner; meaning consisting of many individual learners (trees). The random forest uses multiple random trees classifications to votes on an overall classification for the given set of inputs. In general in each individual machine learner vote is given equal weight.

Table 1: Implemented Classifiers for Activity Recognition System

Implemented Classifier	Relevant Study	Total Relevant Study
Decision Tree	[10, 11, 12,13,14, 15,19,24, 31]	10
Support Vector Machine	[6,11,13,15, 18,24,25,34,38]	9
K-Nearest neighbor	[9,11,13,20,38]	6
Random Forest	[6,12,24]	3
Naïve Bayes	[8,13,19]	3
Neural Network	[13,14]	2
Classification And Regression	[9,36]	2
Multilayer Perceptron	[6,8]	2
HMM Classifier	[14]	1
Simple Logistic	[6]	1
Logic Boost	[6]	1

3. Related Work

Earlier study by Akram Bayat et al. [6] in this work using a smart phone device for collection purpose of accelerometer data from human action recognition, in which gaining accuracy up to 91.15% on conducting several daily routine activities using single triaxial accelerometer. There are various classifiers that have checked for accuracy detection Multilayer Perceptron, SVM, Random Forest, LMT, Simple Logistic, Logic Boost etc.

Earlier work by Ming Zeng et al. [7] proposed a CNN (Convolutional Neural Network) based feature extraction approach, which extracts the local dependency and scale invariant characteristics of the acceleration time series.

Also the work done by Fujimoto et al. [31] provides a human activity recognition system which using a wearable multi sensor with built-in electrocardiograph and triaxial accelerometer. In which the activity recognition method by fuzzy decision tree dependent by fuzzy logic. The data getting from triaxial accelerometer acceleration data that they compute mean acceleration to determine posture of subject.

Earlier work by Huimin Qian et.al [33] Used a system framework is presented to recognize multiple kinds of activities from videos by an SVM multi-class classifier with a binary tree architecture. The framework is composed of three functionally cascaded modules:

- Detecting and locating people by background subtraction approach.
- Extracting several of features including shape information and motion information.
- Recognizing activities of people by SVM multi-class classifier with binary tree architecture.

Earlier work done by Friedman et.al [37] is particularly illustrative, in that it focuses on characterizing how the bias and variance components of the estimation error combine to influence classification performance. For the naive Bayesian classifier, he shows that, under certain conditions, the low variance associated with this classifier can dramatically

mitigate the effect of the high bias that results from the strong independence assumptions.

Also Earlier work done by Gaganjot Kaur et.al [39] this research work has proposed a new approach for efficiently predicting the diabetes from medical records of patients. The Pima Indians Diabetes Data Set has been used for experimental purpose. It has come up with the information of patients with and without having diabetes. The modified J48 classifier has been used to increase the accuracy rate of the data mining procedure. Experimental results have shown a significant improvement over the existing J-48 algorithm. It has been proved that the proposed algorithm can achieve accuracy up to 99.87 %.

The work done by Barry K et.al [40] a basic methodology for analyzing large Multivariate chemical data sets is described. A chromatogram or spectrum is represented as a point in a high-dimensional measurement space. Exploratory data analysis techniques (PCA and hierarchical clustering) are then used to investigate the properties of this measurement space. These methods can provide information about trends present in the data. Classification methods can then be used to further quantify these relationships. The techniques, which have been found to be most useful, are nonparametric in nature.

4. Proposed Methodology

We used the "Human Activity Recognition using smart phones Dataset" (UCI) to build a model [41, 42, 43]. This data was recorded from a Samsung prototype smart phone with a built-in accelerometer. The purpose of this model was to recognize the type of activity (walking, walking upstairs, walking downstairs, sitting, standing, laying) the wearer of the device was performing based on their 3-axial linear acceleration and 3-axial angular velocity at a constant rate of 50Hz, as recorded by the accelerometer wore to the west. This project uses low-cost and commercially available smart phones as sensors to identify human activities. The growing popularity and computational power of smart phone make it an ideal candidate for non-intrusive body-attached sensors. In this project, we design a robust activity recognition system based on a smart phone. The system uses a 3-dimentional smart phone accelerometer, gyroscope as the sensor to collect time series signals, from which features are generated in both time and frequency domain. Activities are classified using different passive learning methods, *i.e.*, Random forest, support vector machine, and artificial neural networks. Dimensionality reduction is performed through both feature extraction and subset selection.

5. Conclusion and Future Works

Human Activity Recognition is vast topic of research. In this review, the use of different feature selection methods and various classifiers for human activity recognition has been investigated. Classification and soft computing approach has been discussed. It is used in real time hence become more interesting as it can use in daily life situation. There is more scope for research in this area.

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