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# A novel approach for Extraction and Classification of ECG signal using SVM

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**ABSTRACT**

In this paper; we propose a highly consistent ECG analysis and classification method using support vector machine. This method is composed of 3 stages including ECG signal preprocessing, feature selection and classification. We have developed a hybrid technique which performs the classification between normal and abnormal ECG. Different features are extracted from human ECG signals using differentfeature extraction techniques. Output of these algorithms is further given to SVM classifier to get it train so that it can accurately classify the test signals between normal and abnormal. The more data is trained; more accuracy will be given. Extracted features mean and kurtosis when classified with SVM-Linear, SVM-Quad, SVM-RBF, SVM-Polynomial gives 100% accuracy; when PCA features skewness & kurtosis, energy & correlation are used with SVM it leads to misclassification of some signals. This technique gives the accurate results but the final decision is made after consultation with medical specialist.

***Keywords:*** ECG, KNN, SVM classifier.

## 1. INTRODUCTION

### 1.1. Electrocardiogram Signal(ECG)

ECG is an electrical signal that produces signal due to the functioning of heart. The human heart is divided into four chambers. Out of these four chambers two are atria named as left atria and right atria, two are ventricles names as left ventricle and right ventricle. The main function of heart is to pump the blood in whole body. Atria parts used for collection of blood from whole body and ventricular parts are for pumping the blood through whole the body parts [1][2][3]. An ECG signal is mainly composed of three waves named as P wave, QRS wave and T wave. These waves produced due to the functions of atria and ventricular parts of hearts. Any disease and abnormality in system affects the original form of ECG waveform.


**Figure 1: One period of an ECG signal.**

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In early 1900s Willem Einthoven developed origin of measuring ECG. Electrocardiogram signal is basically an electrical potential generated during electrical activity done by heart. Electrical signal from different parts of heart in different muscle fibers can be measured using electrodes. For measurement purpose two types of electrodes are used such as limb electrodes and chest electrodes used. The P wave produces due to atrial depolarization and its duration is about less than 120 ms, this wave considered to be of low frequency wave. Due to the depolarization of ventricular part of heart a sharp biphasic or triphasic wave produces named QRS complex having amplitude about 1mV and duration about 70-110 ms. T wave produces due to repolarization of ventricles having duration greater than 300ms and amplitude is about 0.1mV to 0.3 mV. Any abnormality in human system changes the shape of ECG waveform. At rapid heart rate T wave can be closer to QRS complex, position of T wave depends on heart rate. Theraw ECG signal have some noise. To make signal free from any artifacts, firstlypreprocessing have been done.Since P wave produces due to atria contraction, small size of atria P wave has low amplitude about 0.1mV to 0.2 mV.The Sino-atrial (SA) node is the most important and basic part in cardiovascular system that produces action potential and causes the contraction and excitation in heart[5][6].

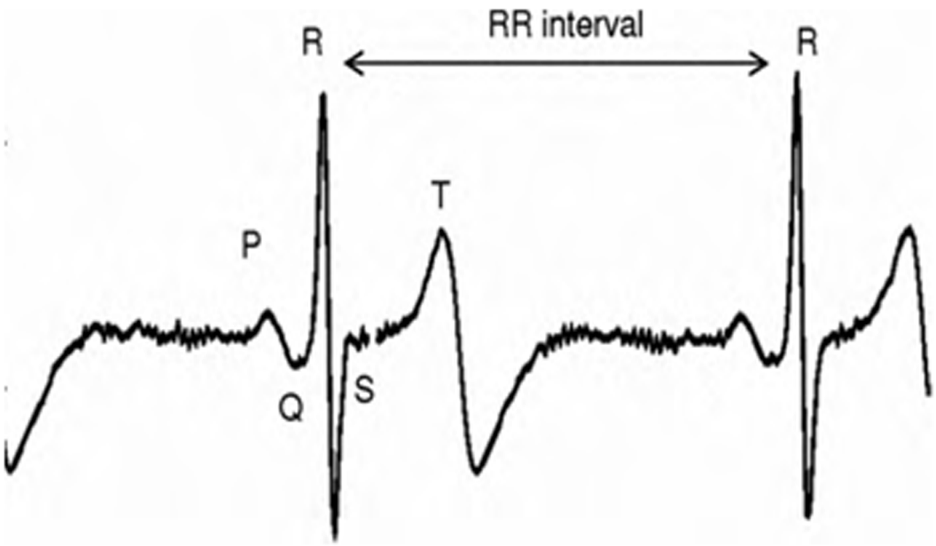



**Figure 2: Components of an ECG signal.**

## 1.2. Noise Sources

ECG signal get alter from different types of noises and artifacts. The raw ECG signal has different type of noise components that must be removed before further processing. To remove these components

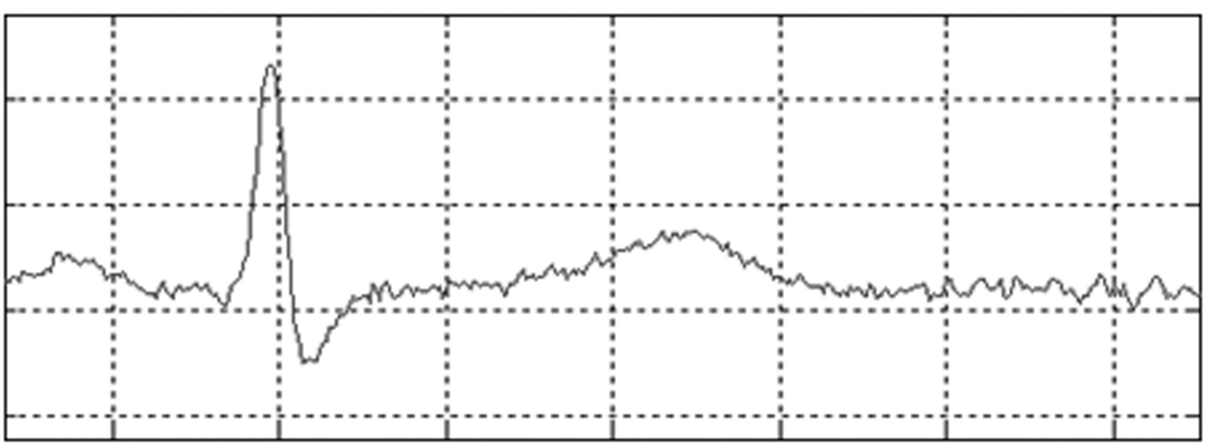
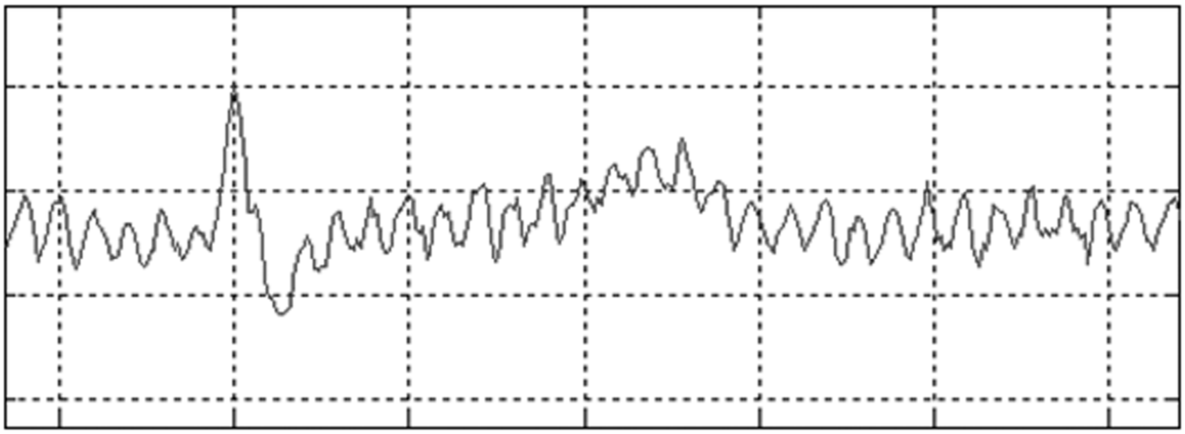


**Figure 3: ECG with high frequency noise.**

preprocessing stage is used, in which using different filters noise can be removed [7][8]. Noise can be baseline wander, Power line interference, Electrode motion artifacts, etc.

### 1.3. Human Identification System

A general human identification system has mainly four steps namely data collection, pre-processing, feature extraction, and classification. A basic diagram for identification purpose is shown in figure (1.5).The data can be collected from Online ECG databases or one can create their own database by measuring ECG signals using different electrodes. Conventionally 12 lead electrodes used to measure ECG signal. The different lead system may be used to measure electrocardiogram signal.



**Figur 4: ECG with power line and high frequency noise .**

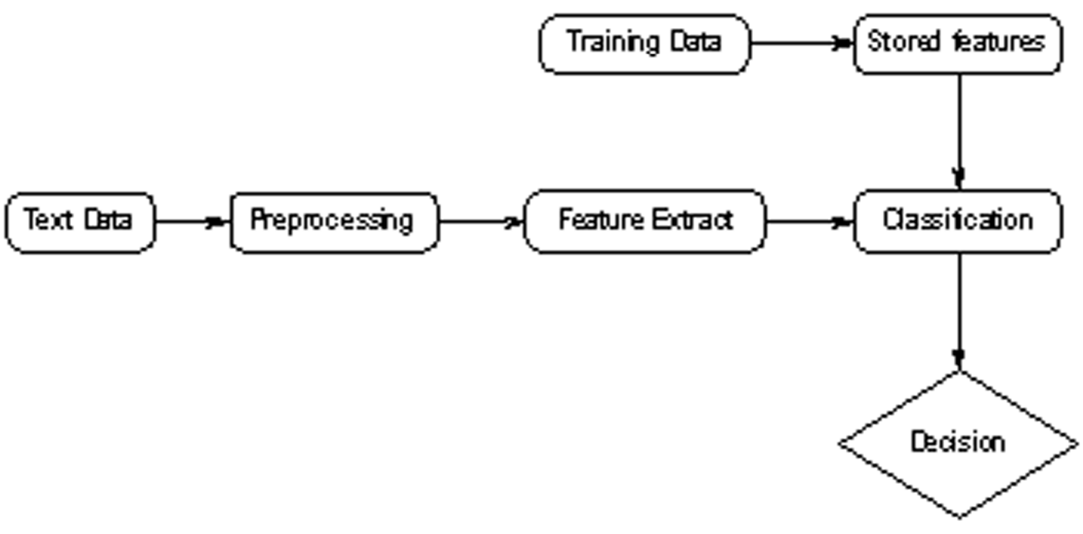



**Figure 5: GeneralBlock diagram of a human identification process.**

## 2. PROPOSED METHOD

### 2.1. ECG Preprocessing

In preprocessing stage different types of filters are used to remove noises from raw ECG signal. High frequency noises and power line interference can be removed by using the Butter worth low pass filter. Thebutterworth filter used for this purpose having varying cut off frequency in the range of 30 to 120Hz. Notch filter can also be used for removing artifacts from raw electrocardiogram signal with cut off frequency of 50Hz and a bandwidth of 10Hz . Butterworth band pass filter can also be used to pass the particular frequency band.[10][11]

### 2.2. Algorithm& classification

For classification between normal and abnormal ECG, different statistical features are extracted from human ECG signals like entropy, mean, kurtosis, skewness, energy, homogeneity and correlation.[12][13]

Support vector machine (SVM) are a set of related supervised learning methods used for classification and regression prediction tool that uses machine learning theory to maximise predictive accuracy while automatically avoiding over-fit to the data. It also uses hypothesis space of a linear functions in a high dimensional features space, trained with a learning algorithm from optimisation theory that implements a learning bias derived from statistical learning theory.SVM is also used for many applications, such as handwriting analysis, face analysis, especially for pattern classification and regression based applications. SVMs were developed to solve the classification problems.[14]

There are different kernel functions used in SVM classification such as: linear, polynomial, gaussian radial basis function, exponential radial basis function, multi layer perceptron.

Classification in SVM is an example of supervised learning. Non labels help indicate whether the system is performing in aright way or not. This information points to a desired response, validating the accuracy of the system to act correctly. A step in SVM classification involves identification as which are intimately connected to the known classes. This is called feature selection or extraction. Feature selection and SVM classification together have a use even when predication of unknown samples is not necessary. They can be used to identify key sets which are involved in whatever processes distinguish the classes.

SVM classifier is used to train the data so that it can accurately classify the test signals between normal and abnormal ECG signals. The more data is trained; more accuracy will be given.

## 3. SIMULATION RESULTS AND DISCUSSION

Extracted features such as mean and kurtosis when classified with SVM-Linear, SVM-RBF gives 100% accuracy; when PCA features skewness & kurtosis, energy & correlation are used with SVM it leads to misclassification of some signals. This technique gives the accurate results but the final decision is made after consultation with medical specialist.

The classification can be done by using smart systems like neural networks. Supervised or unsupervised learning based techniques implemented for classification and decision purpose. Samples

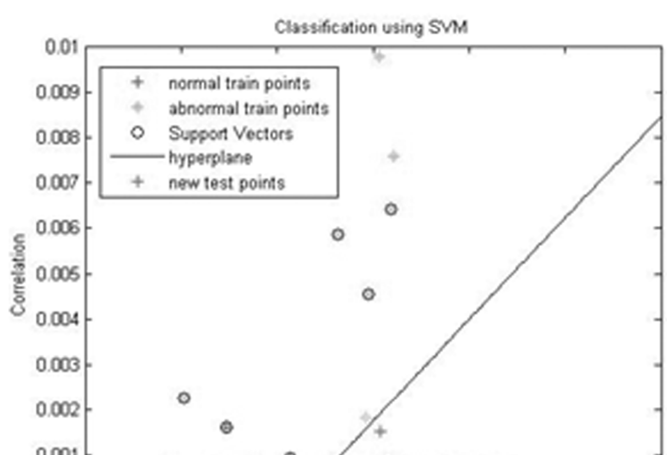



**Figure 6: PCA with Energy-Correlation features using SVM-Linear Kernel function for ECG signals**

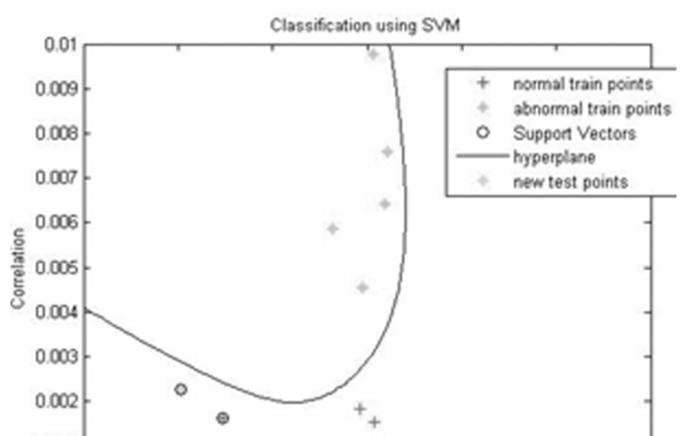



**Figure 7: PCA with Energy-Correlation features using SVM-polynomial Kernel function for ECG signals**

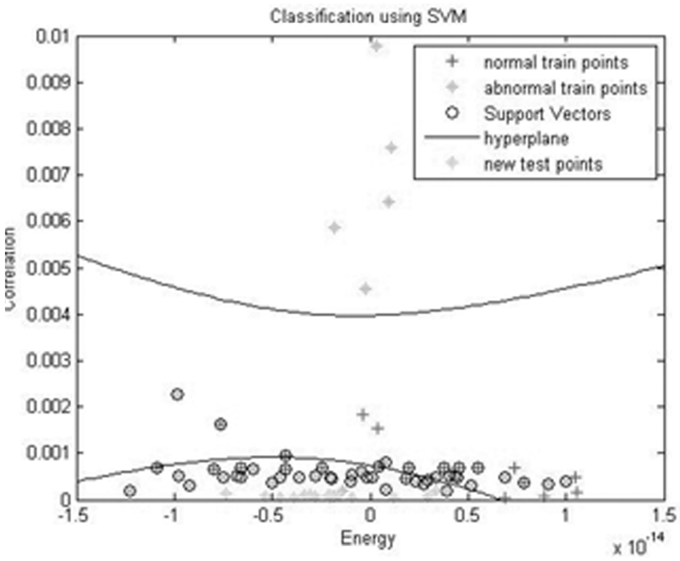



Figure 8: PCA with Energy-Correlation features using SVM-quadratic Kernel function for ECG signals

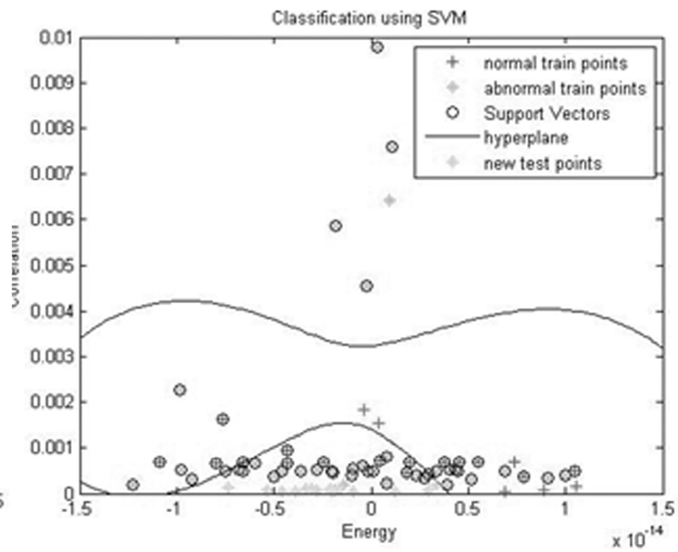



Figure 9: PCA with Energy-Correlation features using SVM-rbf Kernel function for ECG signals

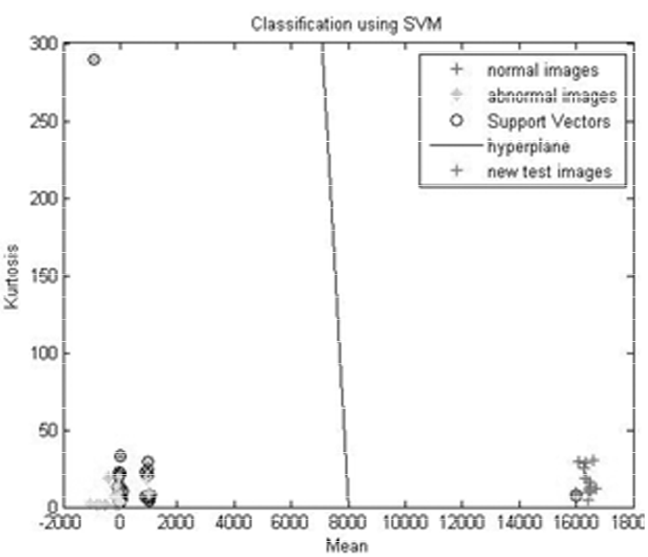



Figure 10: PCA with Mean -kurtosis features using SVM-Linear Kernel function for ECG signals

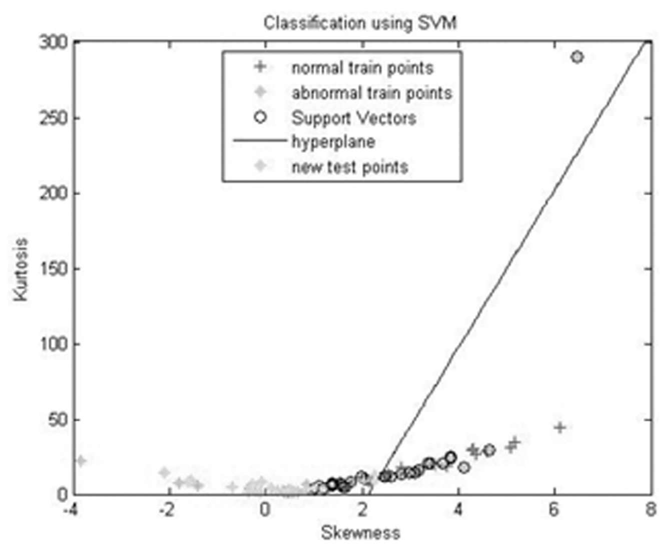



Figure 11: PCA with skewness-kurtosis features using SVM-Linear Kernel function for ECG signals

accepted by algorithm are taken as correct data or acceptance and rejected samples are taken as false data or rejection.

In this section, experimental results of the proposed technique are shown in graphical form for ECG signals using different kernel functions in SVM.

For graphs of human ECG signals; red points denotes data points for normal ECG, green points denotes data points for abnormal ECG and blue points denotes data points for signals data points in test dataset. Black circles are support vectors and lines drawn are hyperplanes.

PCA extracted features mean and kurtosis when classified with SVM-Linear, SVM-Quad, SVM-RBF, SVM-Polynomial gives 100% accuracy with execution time of 5.9687, 5.8999, 5.7759 and 6.0273 seconds resp. in spite of it; when PCA features skewness & kurtosis, energy & correlation are used with SVM it leads to misclassification of some signals.

## 4. CONCLUSION

This work concentates on the classification between normal and abnormal ECG signals. Different features are extracted from human ECG signals using feature extraction technique PCA. Output of these algorithms is further fed to SVM classifier to get it train so that it can accurately classify the test signals between normal and abnormal. The more data is trained; more accuracy will be given. PCA extracted features mean and kurtosis when classified with SVM-Linear, SVM-Quad, SVM-RBF, SVM-Polynomial gives 100% accuracy; when PCA features skewness & kurtosis, energy & correlation are used with SVM it leads to misclassification of some signals. This technique gives the accurate results but the final decision is made after consultation with medical specialist.

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