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Compression And Classification Of Ecg Signal Based On Morphological And Dynamic Features

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Abstract: ECG generated waveforms are used to find patterns of irregularities in cardiac cycle in patients. In order to provide continuous monitoring of cardiac functions for real time diagnosis we propose a methodology that combines compression and analysis of heart beat. In this paper an efficient ECG signal compression method based on wavelet transform is presented. The proposed method combines the adapted SPIHT compression. The tests of this compression can be performed on many ECG records. We propose a new approach for heartbeat classification based on combination of morphological and dynamic features using GK clustering. The GK clustering classifies the signal better than SVM because GK clustering technique compares the training and testing data's not only based on the simple threshold also based on the more number of features for comparison.

Keywords: ECG, Set Partitioning in Hierarchical Tress (SPIHT), GK cluster, Support Vector Machine (SVM)

I INTODUCTION

ECG is one of the most important tools in the diagnosis of heart diseases. It displays the electrical activity of the heart. These signals are recorded from electrodes on the body surface. The ECG signals can be recorded using various lead systems. The ECG generated waveforms are used to find patterns of irregularities in cardiac cycle in patients. Fig 1 shows a recorded normal ECG signal .In many cases irregularities evolves over an extended period of time that requires continuous monitoring. It is well known that modern clinical systems require the storage, processing and transmission of large quantities of ECG signals. ECG signals are collected both over long periods of time and at high resolution. This creates substantial volumes of data for storage and transmission. Data compression seeks to reduce the number of bits of information required to store or transmit digitized ECG signals without significant loss of signal quality. Although storage space is currently relatively cheap, electronic ECG archives could easily become extremely large and expensive. Moreover, sending ECG recordings through mobile networks would benefit from low bandwidth demands. ECG signal compression attracted considerable attention over the last decade. The commonly used Compression methods are Discrete Wavelet Transform (DWT), Wavelet decomposition and many more [7] [13]. We propose an efficient compression method for ECG signals based on SPIHT (set partitioning hierarchical trees).The SPIHT method is based on the use of wavelet transform which is very well suited to locate the energy of the signal in fewer coefficients. [11]

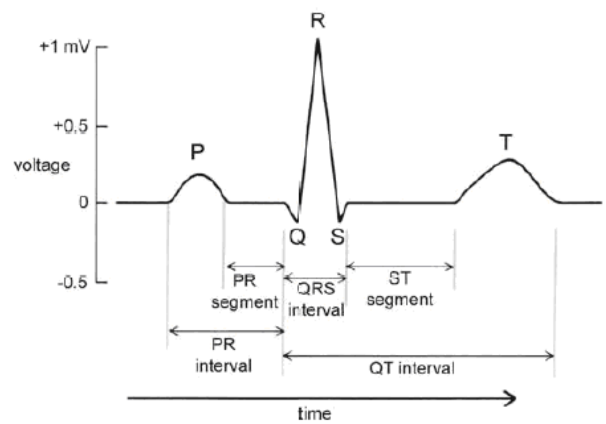

Fig 1: A Normal ECG waveform

Besides noise, the main problem in computer-based classification of heart beats in ECG recordings is the wide variety in the shape of beats belonging to a given class and the similarity in the shape of beats belonging to different classes. Therefore, algorithms for computer-based diagnosis generally have three steps: ECG beat detection, extraction of useful features from beats, and classification. A number of methods have been developed for beat detection. Feature extraction can be done in the time domain, in the frequency domain, by multiscale decomposition, by multifractal analysis, or by statistical means. Classification can be performed using neural networks, a mixture of experts' model. In order to classify the abnormalities we need the features to be extracted from the ECG signals. The features may be dynamic features or the morphological features [3]. This includes the first order features such as Mean, Standard deviation, Covariance etc and R-R interval. When the features extracted are more the classification accuracy is more. Data clustering is considered as an interesting approach for finding similarities in data and putting similar data into groups. Clustering partitions a data set into several groups such that the similarity within a group is larger than that among groups. The normally used classifiers are Support Vector Machine (SVM), Linear Discriminant Analysis (LDA), neural

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networks. This work includes the use of Fuzzy based GK clustering. This shows improved result when compared to the others. The simulation software used here is MAT LAB.

II MATERIALS AND METHODS

The whole idea is to compress the ECG signal and classify the signal based on the features extracted from the signal. The first step is to preprocess the signal to remove the noises. The preprocessed signal is compressed using SPIHT method and various compression methods. The features are extracted from the signal. The classifier is trained with the extracted features .The classifier used here is GK cluster. Now the classifier is tested with input signal. They are classified into normal and abnormal signals. Fig 2 shows the flow diagram of the whole setup.

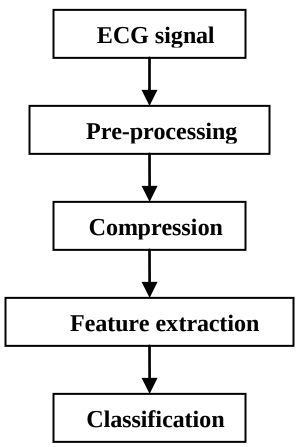

Fig 2: Flow diagram of the whole setup.

A. PREPROCESSING:

The ECG signals are taken from the standard MIT BIH arrhythmia database. The database consists of 48 fully annotated, 30 min, two-lead ECG recordings from 47 different patients (recordings 201 and 202 are from the same patient). The leads usually involve the modified limb lead II (MLLII) and one of the modified leads V1, V2, V4, or V5 [1]. Since the second lead usually varies for each recording (patient), all the results in this paper are based on the MLLII. The data are sampled at 360 Hz and the ±5mV range is quantized to 11 bits [2] [1]. Fig 3 shows the raw input ECG signal The ECG signals are affected by various noise sources such as Baseline drift which is caused by slow varying frequency components, EMG noise which is caused by the muscle contraction and finally Motion artifacts which introduce severe noise in the signal. The main problem of digitalized signal is interference with other noisy signals like power supply network 50 Hz frequency and breathing muscle artifacts. These noisy elements have to be removed before the signal is used for next data processing like heart rate frequency detection. Here we have used low pass filter to reduce the amplitude levels of the signal. Fig 4 shows the filtered ECG signal.

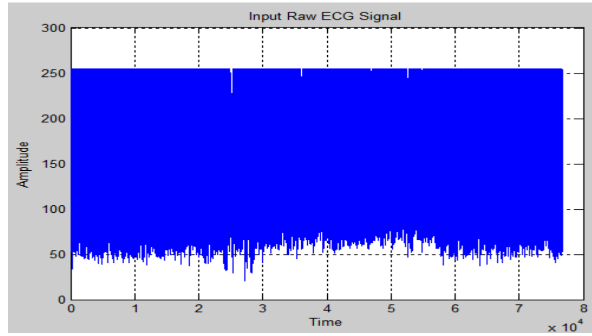

Fig 3: Input raw ECG signal

B. COMPRESSION:

Various compression algorithms are used to compress the ECG signal. The commonly used are Discrete Wavelet Transform (DWT), Fourier Transform (FT), and Wavelet Decomposition and so on. This paper provides a Wavelet based compression algorithm, SPIHT (Set Partitioning In Hierarchical Trees). SPIHT is a coding technique, developed by Said and Pearlman, which order the transform coefficients using a set partitioning algorithm based on the sub-band pyramid.[11] By sending the most important information first of the ordered coefficients, the information required to reconstruct the image is extremely compact. SPIHT is also one of the fastest codec's available and provide user selectable file size or image quality and progressive image resolution and transmission. SPIHT is based on three concepts: 1) partial ordering of the image coefficients by magnitude and transmission of order by a subset partitioning algorithm that is duplicated at the decoder. 2) Ordered bit plane transmission of refinement bits, and 3) exploitation of the self-similarities of the image wavelet transform across different scales [12]. In this paper SPIHT is applied to1D signal. The transformed coefficients are compressed and encoded. And hence this gives us the compressed signal. Fig 5 shows the compressed signal

C. FEATURES EXTRACTED:

Feature extraction is the major steps carried out in order to classify the ECG signal. The features extracted in this paper are Dynamic features and Morphological features. That is the first order features namely Mean, Variance, Standard deviation and Beat rate.

1. Arithmetic mean:

In simple terms, the arithmetic mean of a list of numbers is the sum of all the members of the list divided by the number of items in the list. If a set of data is denoted by $X = (x1, x2,.. xn)$, then the sample mean is typically denoted with a horizontal bar over the variable

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i = \frac{1}{n}(x_1 + \cdots + x_n)$$

2. Variance:

The variance of a sample is one measure of statistical dispersion, averaging the squared distance of its possible values from the expected value (mean). Whereas the mean is a way to describe the location of a distribution, the variance is a way to capture its scale or degree of being

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spread out. The unit of variance is the square of the unit of the original variable. If random variable X has expected value (mean) μ = E(X), then the variance Var(X) of X is given by:

$$\mathrm{Var}(X) = \mathrm{E}[(X-\mu)^2]$$

3. Standard deviation:

The standard deviation of a multiple set of values is a measure of statistical dispersion of its values. The standard deviation is usually denoted with the letter σ. It is defined as the square root of the variance

$$\sigma = \sqrt{\mathrm{E}((X-\mathrm{E}(X))^2)} = \sqrt{\mathrm{E}(X^2) - (\mathrm{E}(X))^2}$$

where E(*X*) is the expected value of *X.* Standard deviation, being the square root of variance, measures the spread of data about the mean, measured in the same units as the data [14]. Along with the above mentioned features Beat rate is also extracted from the input ECG signal. That is the R-R interval is extracted from the signal. The R-R interval is the distance between the consecutive R peaks of the ECG signal. And hence based on the four features extracted namely, Mean, Variance, Standard deviation and Beat rate the signal are classified by the GK cluster.

D. CLASSIFICATION:

The widely used classifiers are support vector machine (SVM), Linear Discriminant Analysis (LDA) and so on. This paper gives the fuzzy classifier called GK cluster. There are different clustering techniques such as k-means clustering, fuzzy c-means clustering, subtractive clustering, histogram adaptive smoothing and mountain clustering. Gustafson and Kessel (Gustafson and Kessel, 1979) extended the standard fuzzy *c* means algorithm by employing an adaptive distance norm, in order to detect clusters of different geometrical shapes in one data set. The Gustafson-Kessel algorithm associates each cluster with both a point and a matrix, respectively representing the cluster centre and its covariance. Whereas the original fuzzy c-means make the implicit hypothesis that clusters are spherical, the Gustafson- Kessel algorithm is not subject to this constraint and can identify ellipsoidal clusters [15]. The features extracted are used to train the classifier. The used features are named as trained data after training the classifier is tested with the input ECG signal. The end result of the classifier could be either the input ECG signal is normal or abnormal. The performance measure of the classifier can be calculated by predefined formulas. It could be measured in terms of Accuracy, Sensitivity and Specificity etc

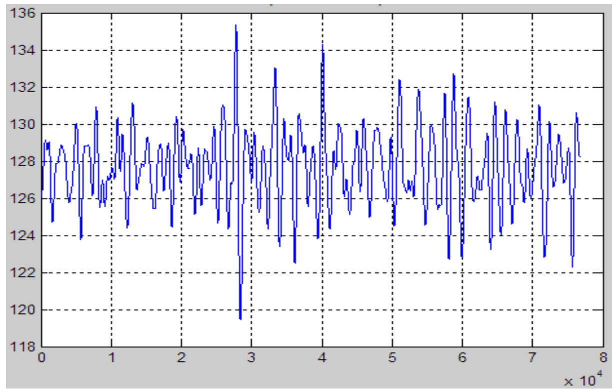

Fig 4: Filtered ECG signal

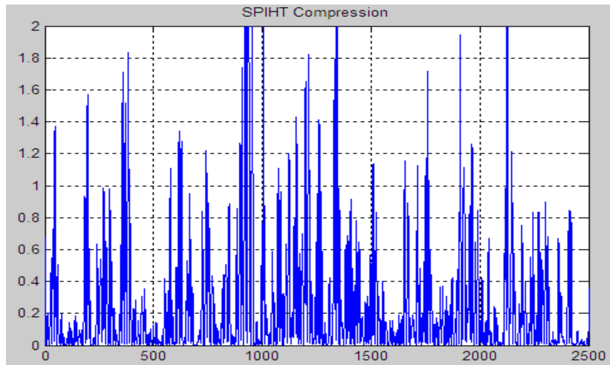

Fig 5: Compressed ECG signal

III RESULTS AND DISCUSSION

This paper provides a method of compression and classification of ECG signals. The input ECG is filtered to get rid of noise .The filtered ECG signal is compressed by SPIHT compression. Fig 4 shows the filtered signal. The features extracted are Mean, Standard deviation, Covariance and Beat rate. These features are used to train the classifier. The classifier used here is GK cluster. The input ECG is tested with the classifier. The result is displayed such that whether it is normal or abnormal. The fig 5 shows the compressed ECG signal. The above mentioned results belong to the MIT BIH arrhythmia database. The shown results are of patient record 100.mat.this method could be tested with various ECG signals available in MIT BIH database. This method can be simulated in MAT LAB software. When this method applied to various ECG signals the performance measure could be calculated and compared with the available results. The expectation is the improved accuracy. Since this method shows improved accuracy when tried with two ECG signals. One is the normal ECG signal and the other is abnormal ECG signal. The performance of the classifier can be measured by the pre defined metrics such as Accuracy, Sensitivity and Specificity etc

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REFERENCES

[1]. ”Time-based compression and classification of heartbeats” alexandersingh alvarado, choudur lakshminarayan, and jos´e c. Pr´incipe, fellow, ieee.

[2]. “Ecg biometric recognition: a comparative analysis”, ikenna odinaka, student member, ieee, po-hsiang lai, student member, ieee, aland.kaplan, member, ieee,joseph a. O’sullivan, fellow, ieee, erik j.

[3]. ”Heartbeat classification using morphological anddynamic features of ecg signals”, can ye,student member,ieee,b.v.k.vijaya kumar,fellow , ieee, and miguel tavares coimbra,member,ieee.

[4]. ”Surface electrocardiogram reconstruction from intracardiac electrograms using a dynamic timedelay artificial neural network”, fabienne por´ee, amar kachenoura, guy carrault, renzo dal molin, philippe mabo, and alfredo i. Hern´andez.

[5]. ”Diagnosis of cardiovascular abnormalities from compressed ecg: a data mining-based approach”, fahim sufi and ibrahim khalil.

[6]. ”Electrocardiogram (ecg) signal processing “, leif so ¨ rnmo lund university swede pablo laguna zaragoza university spain.

[7]. ”Ecg signals processing using wavelets”, gordan cornelia, reiz romulus university of oradea: electronics department, faculty of electrical engineering and information technology,oradea, romania.

[8]. ”The principles of qrs complex detection”,bert-uwe köhler, carsten hennig,reinhold orglmeister department of electrical engineering,biomedical electronics group, berlin university of technology

[9]. ”Ecg signal processing and heart rate frequency detection methods”, j. Parak, j. Havlik department of circuit theory, faculty of electrical engineering czech technical university in prague.

[10]. ”Wireless medical-embedded systems: a review of signal-processing techniques for classification”, hassan ghasemzadeh, member, ieee, sarah ostadabbas, student member, ieee,eric Guenterberg, Student Member, IEEE, and Alexandros Pantelopoulos, Member, IEEE.

[11]. ”Implementing of SPIHT and Sub-band Energy Compression (SEC) Method on Two-Dimensional ECG Compression: A Novel Approach”, Iman mohammad rezazadeh1, mohammad hassan moradi2 and ali motie nasrabadi3.

[12]. ”Wavelet compression of ecg signals by the set partitioning in hierarchical trees (spiht) algorithm”,zhitao lu,dong youn kim and william a.pearlman

[13]. ”Wavelet-based low-delay ecg compression algorithm for continuous ecg transmission”, byung s. kim, sun k. yoo, and moon h. lee

[14]. “Classification of ECG Signals using ANN with Resilient Back Propagation Algorithm”, G. Subramanya Nayak Department of EC Engineering MIT, Manipal International Journal of Computer Applications (0975 – 8887)

[15]. “Gustafson-Kessel-like clustering algorithm based on typicality degrees “, Marie-Jeanne Lesot FIN, Otto-von-Guericke Universit¨ at, Magdeburg, Germany