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Cardiac Abnormality Detection System for Compressed ECG Using Fuzzy Inference System

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ABSTRACT: Compressed Electrocardiography (ECG) is being used in modern telecardiology applications for faster and efficient transmission. ECG diagnosis algorithms require the compressed ECG packets to be decompressed before diagnosis can be applied. This additional process of decompression before performing diagnosis for every ECG packet introduces undesirable delays, which can have severe impact on the longevity of the patient. ECG signal analysis has shown an important role in the prognosis, diagnosis and survival analysis of heart diseases. ECG signal compression is required due to three main reasons: low storage data space, reduction of low data transmission rate and transmission bandwidth conversation. The electrocardiogram (ECG) signal compression using clustered under Premature Contraction (PC), Premature Ventricular Contraction (PVC), and Arterial Flutter (AF) is presented in this paper. Principal Component Analysis (PCA) technique is used for dimensionality reduction and data classification. The methods are applied to the MIT/BIH arrhythmia ECG database. The results are efficient promising that this approach can useful for data compression of ECG signals. The experimental results are analyzed on the basis of Percentage of root mean square difference (PRD and compression ratio (CR).

KEYWORDS: Compressed Electrocardiography, Compression Ratio, Electrocardiogram, Fuzzy Inference System, And Medical Data Mining.

I. INTRODUCTION

In a medical environment, there are several signals which must be constantly or periodically supervised. Some of the most common are the temperature, the concentration of oxygen in blood, the arterial pressure or the electrocardiogram waveform. It is under this scenario that this thesis is developed. In this case, there is an implemented system of acquisition of electrocardiogram (ECG) and phonocardiography (PCG) signals, which must be wirelessly and error-free sent to the required medical location. The ECG (Electrocardiogram) is a biological signal. It is the electrical activity of the heart.

II. RELATED WORK

A method to measure and record different electrical potentials of the heart. The human heart contains four chambers: left atrium, right atrium, left ventricle and right ventricle. Blood enters the heart through two large veins, the inferior and superior vena cava; emptying oxygen-poor blood from body into the right atrium. From the right atrium, the oxygen deficient blood enters the right ventricle. The right ventricle then pushes the blood into the lungs. Inside the lungs a process called _gas exchange' occurs and the blood replenishes oxygen supply.[1] The oxygen rich blood then enters left atria. From the left atria, blood rushes into the left ventricle. Finally, it is the left ventricle that forces the oxygenated blood to the rest of the body. This mechanical activity of the human heart is powered by electrical stimulations inside the heart. [4]

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The Depolarization (electrical activity) of a specific portion of the heart (either atria or ventricle) results in mechanical contraction of that specific part. Again, depolarization results in the mechanical relaxation of the heart chambers. ECG acquisition devices basically pick up these electrical activities via sensors attached to the human skin and draws the electrical activities in kilovolt ranges. During the regular activity of the heart, both the atria contract together, followed by ventricular contraction (both the ventricles contract together) [2].
The ECG signal analysis and classification system provides basic features (amplitudes and time intervals) to be used in resultant automatic analysis. The 'Electrocardiogram' is an invaluable tool of diagnosis of heart diseases [1].

The main purpose of compression is to represent an ECG data with the smallest possible number of bits. It can assist the transmission and processing of signal. Many types of ECG recordings generate a vast amount of data. While ECG system found primarily in hospitals, they find use in many other medical centre's also. These are also used by clinician at remote sites. Certain military and/or space mission also employ ECG.A growing area of use for ECG is 24-hour Halter recordings, telemetry recordings, continuous ECG performed in intensive care units and stress test ECG. With the growing use of these ECG signals to detect and diagnose heart disorders.The compression technique is to achieve maximum data reduction while preserving the significant signal morphology features upon reconstruction. Data compression methods can classified into two main families: lossless and lossy methods. Methods from the lossless can obtain an exact reconstruction of the original signal, but they do not get low data rates. In contrast, lossy methods do not obtain an exact reconstruction, but higher compression ratios can obtained. The commonly used ECG compression techniques are lossy in nature.[3]

From last decade, a number of methodologies have been proposed to detect features of ECG signal such as amplitude and time interval. It is not always adequate to study only time domain method for ECG signal analysis, so there is need of frequency domain representation because small deviation on normal ECG signal means cardiac disorders [5].Changes in ECG reflect the abnormality introduced in the functioning of heart, making diagnosis and treatment of the patient easier. For all types of cardiac disorders and troubles indirectly associated with the heart, doctors advise the patient to have the ECG recorded before complete diagnosis of the patient. ECG analysis has therefore become a preliminary and mandatory requirement for the diagnosis of subjects [6].

Ramli et al. in [12] investigate the use of signal analysis technique to extract the important features from the 12 lead system (electrocardiogram) ECG signals. Lead II is chosen for the whole analysis due to it representative characteristics for identifying the common heart diseases. The analysis technique chosen is the cross-correlation analysis. Cross-correlation analysis measures the similarity between the two signals and extracts the information present in the signals. Results show that the parameters signal analysis technique extracted could clearly differentiate between the types of heart diseases analyzed and also for normal heart signal.

III. PROPOSED METHODOLOGY

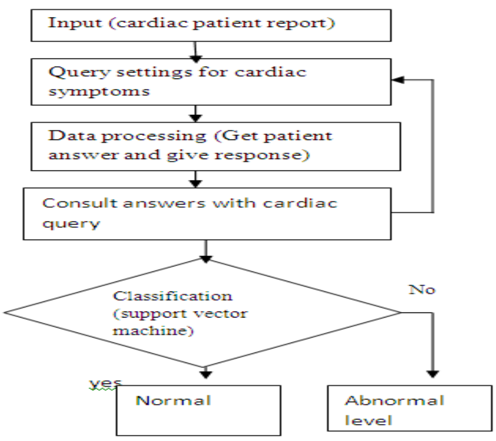

Fig. 1. Block Diagram of the proposed system

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For each intersection point between the mesh and the image, our system considers an image patch, centered on this point. Thus, a large number of patches from

3.1. Input

The stack of images is sampled. Patch size was selected such that myocardium pixels, pixels from the blood pool and / or air in the lung are included in the patch.

3.2. Electrocardiogram signal

An Electrocardiogram is also called an EKG or ECG. Electrocardiography (ECG or EKG) is an electrical activity of the heart over a period of time, as detected electrodes attached to the surface of the skin and recorded by a device external to the body. It is a simple, painless test that records the heart's electrical activity. The recording produced by this noninvasive procedure is termed an electrocardiogram (ECG or EKG). An ECG is used to measure the regularity of heartbeats, as well as the position and size of the chambers, the presence of any injure to the heart, and the effects of devices used to regulate the heart, such as a pacemaker [2].Most ECGs are performed for diagnostic or research purposes on human heart, but may also be used performed on animals, usually for prognosis of heart abnormalities or research. Figure below show normal human electrocardiogram waveform.

An ECG is a way to measure and diagnose abnormal rhythms of the heart, particularly abnormal rhythms means damage to the conductive tissue that carries electrical signals, or abnormal rhythms means by electrolyte unbalances. In a myocardial infarction (MI), the ECG can identify if the heart muscle has been damaged in specific areas, though all the areas of the heart are not covered. The ECG cannot reliably measure the pumping ability of the heart, for which ultrasound-based (echocardiography) or nuclear medicine tests are used. It is possible for a human to be in cardiac arrest, but still have a normal ECG signal (a condition known as pulse less electrical activity) [2]. The output of an ECG recorder is a graph with time represented on the x-axis and voltage represented on the y-axis. The result of electrical activity is P, QRS, and T waves that are of different sizes and shapes. The height of an ECG wave is called its amplitude [2]. The amplitude of isoelectric line is considered zero. Anything above the isoelectric line is positive.

3.3. ECG Data Compression

ECG Data Compression: There are two types of data compression technique namely lossless compression and loss compression. Lossless data compression is classes of data compression algorithms that allow the exact original data to be reconstructed form the compressed data. In lossless compression technique original data after compression and decompression are found exactly same form. Lossless method is used when we cannot afford to lose any data legal and medical document computer program [1]. Figure 2 shows the block diagram of lossless compression of signal. Wave Amplitude P wave 0.25mv R wave 1.60mv Q wave 25% of R wave T wave 0.1 t 0 0.5mv However, the techniques that do not permit perfect reconstruction of the original signal are called lossy compression. Loss compression provides much higher compression ratios than lossless. Loss of information is acceptable in a picture of video. Lossy schemes are widely used since the quality of the reconstructed signal is adequate for most applications [1]. The following are the requirement to be fulfilled in any compression data strategy:

1. Information preservation: Due to diagnostic restriction, it is imperative that the information found in the original data is preserved after compression [5].
2. Control of compression degree: Another preference is the ability to control the amount of data compression. Current information is preferably stored in a data exact form with low degree of compression. However, with older data a more aggressive compression strategy is accepted [5].
3. Complexity Issue: Due to limited processing capacity of the pacemaker, an algorithm for compressing data has to have low complexity [5].

3.4. Fuzzy Inference System

To determine the location of the transition from blood to myocardium or from myocardium to air, gray values are first classified. To ensure modality independence, only relative gray value differences between blood, myocardium and air are used. To distinguish between three classes, and use the class transitions as borders.[6] The classes used are bright, dark, and medium bright, which represent blood pool, cardial border: from outside to inside, for all spatial

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vertex locations, find first transition from myocardium to blood pool epicardial border: from inside to outside, at the septum, find first transition from myocardium to blood pool, at the lateral wall, find first transition from myocardium to air, at the inferior wall, interpolate septum and lung candidates Cardiac Image patches from a cardiac short axis image slice. In the left circle, the true pixel gray.[7] The minimum membership degree for a pixel to be effectively classified is 0.5 for blood and air and 0.7 for myocardium. If a pixel does not have the required minimum membership value it is not classified (fuzzy border) and thus not considered for inference. The new candidate point resulting from this decision scheme is located at the transition found. If no position can be generated because of the lack of a proper transition in the image patch, the particular model point is updated using the result from neighboring patches in the model for which a decision could be made. Left, an image patch with classified pixels is shown. The pixels are classified to blood (0), myocardium (1), and air (2) or none (empty) (part 1 of the inference step). The right patches classified lines according to part 2 of the inference step. The darker lines (below) are air, the medium bright lines are myocardium, and the bright lines are blood pool. In the patch, which is centered on the model surface (indicated with arrow), a new candidate position is found.[8]

For each pixel, three fuzzy membership degrees (FMDs) result from the fuzzification, above. Based on these FMDs, the inference step looks like:
1. for each pixel
If (gray value is bright) then pixel is blood pool
If (gray value is medium) then pixel is myocardium
If (gray value is dark) then pixel is air
2. for each line
If (majority of pixels is class i) then line is class i
Else line is unclassified
3. Transition
Endo

3.5. Measure of performance

One of the most difficult problems in ECG compression applications and reconstruction is defining the error criterion.[9] The main purpose of the compression system is to remove redundancy and irrelevant information. The error criterion has to be defined so that it will measure the ability of the reconstructed signal to preserve the relevant information. ECG signals generally are compressed with lossy compression algorithms, a way of quantifying the difference between the original and the reconstructed signal, often called distortion [10].

3.6. Percentage of root mean square difference (PRD):

PRD is one of the important parameters of any algorithms analysis and the small value of PRD shows success of algorithm[11]. The most common used distortion measure is the Percent Root mean square Difference (PRD) that is given by Where N is the number sample of data.[12]

Number of bits required = log2 (abs (max (output))) +1

The output signal is one fourth length that of its original signal and taken data specified with 12 bit resolution (one bit for sign) [13].

IV. CONCLUSION

In this paper, ECG data compression proposed scheme based on principal component analysis (PCA) algorithm. The effectiveness and performance of an ECG data compression evaluated compression ratio (CR) and percent root mean square difference (PRD). The parameters most commonly used by the international community like percent root mean square difference (PRD) and compression ratio (CR). If ECG data compression high-compression ratio (CR) and low PRD i.e. ECG data good compressed.

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