Divide And Conquer Algorithm Based an Efficient Scheme for Compression of Electro Cardiac Signal

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ABSTRACT

An electrocardiogram (ECG) is a standard test that checks how the heart is working by measuring the electrical action of the heart. Individuals with a heart related issues have the long record of ECGs for symptomatic purposes, which brings about the necessity of a lot of storage space. Subsequently there is a requirement for a framework which includes pressure of ECG signals alongside ECG investigation. ECG pressure is a superior technique for minimize computational many-sided quality as far as storage. Flag pressure and flag examination have request in numerous application territories particularly in biomedical zone. ECG signals are diverse for every individual. ECG design acknowledgment is a standout amongst the most dependable coronary illness recognizable proof strategies. ECG is the standard tool for monitoring and diagnosing cardiovascular issues by measuring electrical movement of the heart. The cathodes connected to the body identify the electrical movement of the heart. From every terminal the ECG signals will record and store for a drawn out stretch of time.

Recording process of heart electrical activity over a period using electrodes that have been placed in skin is known as Electrocardiography (ECG). It is necessary to handle huge amount of ECG data in continuous patient monitoring. Hence, we need to store more data as every time that we need to monitor the patient heart condition. But storing, transmitting, and allocating bandwidth to this Meta data is very expensive. To resolve this issue, here an efficient compression technique has been implemented in such a way that can retain all the salient features which have been required clinically. For testing the ECG, we have used the MIT-BIH ECG data base.

Keywords: Electrocardiogram (ECG), conquer algorithm, patient heart condition.

1. INTRODUCTION

An electrocardiogram (ECG) is a standard test that checks how the heart is working by measuring the electrical action of the heart [1] and [2]. Individuals with a heart related issues have the long record of ECGs for symptomatic purposes, which brings about the necessity of a lot of storage space. Subsequently there is a requirement for a framework which includes pressure of ECG signals alongside ECG investigation. ECG pressure is a superior technique for minimize computational many-sided quality as far as storage. Flag pressure and flag examination have request in numerous application territories particularly in biomedical zone [3]. ECG signals are diverse for every individual. ECG design acknowledgment is a standout amongst the most dependable coronary illness recognizable proof strategies. ECG is the standard tool for monitoring and diagnosing cardiovascular issues by measuring electrical movement of the heart [4]. The cathodes connected to the body identify the electrical movement of the heart. From every terminal the ECG signals will record and store for a drawn out stretch of time. Preparing of ECG flag by utilizing existing ECG library data comprises of ECG waveforms parameters like P wave, QRS complex and T wave [5], [6] and [7]. In this, QRS complex is most essential part which demonstrates the electrical depolarization of the ventricle muscles in the heart. The duration and stature of QRS gives critical measure of data to doctor in this manner he/she can undoubtedly comprehend the state of heart. A cardiovascular patient with the history of heart infections will dependably need to keep up a ton of ECG reports while going to a doctor for interview. We will likely outline a framework which includes pressure of ECG signals for ordering typical and strange classes of ECG signals. Digitizing the ECG flag will take care of the storage issue and it likewise gets to be practical when comes to sharing and finding.

The graphical recording of bioelectrical possibilities generated by heart on the surface of the body is called ECG (Electro-Cardiogram). An ordinary mechanized flag handling framework gets a lot of data that is hard to store and transmit. Here comes the significance of data pressure. Data pressure is the way toward recognizing and disposing of redundancies in a given data set. Through this data pressure method framework needs to accomplish greatest data volume lessening while protecting noteworthy data. The requirement for flag pressure exists in many transmitting and storage applications. Expansive measure of ECG information needs to effectively store in healing facilities for monitoring reasons. The ECG monitoring gadget must have a memory limit of 200 Mbytes for three lead recordings.

Normally, the frequency range of an ECG signal is of 0.05–100 Hz and its dynamic range – of 1–10 mV. The ECG signal is characterized by five peaks and valleys labelled by the letters P, Q, R, S, T. In some cases, we also use another peak called U. The performance of ECG analyzing system depends mainly on the accurate and reliable detection of the QRS complex, as well as T- and P waves. The P-wave represents the activation of the upper chambers of the heart, the atria, while the QRS complex and T-wave represent the excitation of the ventricles or the lower chamber of the heart. The detection of the QRS complex is the most important task in automatic ECG signal analysis. Once the QRS complex has been identified a more detailed examination of ECG signal including the heart rate, the ST segment etc. can be performed. In the normal sinus rhythm (normal state of the heart) the P-R interval is in the range of 0.12 to 0.2 seconds. The QRS interval is from 0.04 to 0.12 seconds. The Q-T interval is less than 0.42 seconds, and the normal rate of the heart is from 60 to 100 beats per minute.

So, from the recorded shape of the ECG, we can say whether the heart activity is normal or abnormal. The electrocardiogram is a graphic recording or display of the time variant voltages produced by the myocardium during the cardiac cycle. The P-, QRS- and T-waves reflect the rhythmic electrical depolarization and re-polarization of the myocardium associated with the contractions of the atria and ventricles. This ECG is used clinically in diagnosing various abnormalities and conditions associated with the heart.

2. DATA COMPRESSION

Lossy And Lossless Compression

Image compression may be lossy or lossless. Lossless compression is preferred for archival purposes and often for medical imaging, technical drawings, clip art, or comics. Lossy compression methods, especially when used at low bit rates, introduce compression artifacts. Lossy methods are especially suitable for natural images such as photographs in applications where minor (sometimes imperceptible) loss of fidelity is acceptable to achieve a substantial reduction in bit rate. The lossy compression that produces imperceptible differences may be called visually lossless.

Data Compression

In computer science and information theory, data compression, source coding, or bit-rate reduction involves encoding information using fewer bits than the original representation. Compression can be either lossy or lossless. Lossless compression reduces bits by identifying and eliminating statistical redundancy. No information is lost in lossless compression. Lossy compression reduces bits by identifying unnecessary information and removing it. The process of reducing the size of a data file is popularly referred to as data compression, although its formal name is source coding (coding done at the source of the data before it is stored or transmitted).

Compression is useful because it helps reduce resource usage, such as data storage space or transmission capacity. Because compressed data must be decompressed to use, this extra processing imposes computational or other costs through decompression; this situation is far from being a free lunch. Data compression is subject to a space–time complexity trade-off. For instance, a compression scheme for video may require expensive hardware for the video to be decompressed fast enough to be viewed as it is being decompressed, and the option to decompress the video in full before watching it may be inconvenient or require additional storage. The design of data compression schemes involves trade-offs among various factors, including the degree of compression, the amount of distortion introduced (*e.g.*, when using lossy data compression), and the computational resources required to compress and uncompress the data. New alternatives to traditional systems (which sample at full resolution, then compress) provide efficient resource usage based on principles of compressed sensing. Compressed sensing techniques circumvent the need for data compression by sampling off on a cleverly selected basis.

Lossless

Lossless data compression algorithms usually exploit statistical redundancy to represent data more concisely without losing information, so that the process is reversible. Lossless compression is possible because most real-world data have statistical redundancy. For example, an image may have areas of colour that do not change over several pixels; instead of coding "red pixel, red pixel, the data may be encoded as "279 red pixels". This is a basic example of run-length encoding; there are many schemes to reduce file size by eliminating redundancy.

Lossy

Lossy data compression is the converse of lossless data compression. In these schemes, some loss of information is acceptable. Dropping nonessential detail from the data source can save storage space. Lossy data compression schemes are informed by research on how people perceive the data in question. For example, the human eye is more sensitive to subtle variations in luminance than it is to variations in color. JPEG image compression works in part by rounding off nonessential bits of information. There is a corresponding trade-off between preserving information and reducing size. A number of popular compression formats exploit these perceptual differences, including those used in music files, images, and video.

Lossy image compression can be used in digital cameras, to increase storage capacities with minimal degradation of picture quality. Similarly, DVDs use the lossy MPEG-2 Video codec for video compression.

Video

Video compression uses modern coding techniques to reduce redundancy in video data. Most video compression algorithms and codecs combine spatial image compression and temporal motion compensation. Video compression is a practical implementation of source coding in information theory. In practice, most video codecs also use audio compression techniques in parallel to compress the separate, but combined data streams as one package.

Encoding Theory

Video data may be represented as a series of still image frames. The sequence of frames contains spatial and temporal redundancy that video compression algorithms attempt to eliminate or code in a smaller size. Similarities can be encoded by only storing differences between frames, or by using perceptual features of human vision. For example, small differences in color are more difficult to perceive than are changes in brightness. Compression algorithms can average a color across these similar areas to reduce space, in a manner similar to those used in JPEG image compression. Some of these methods are inherently lossy while others may preserve all relevant information from the original, uncompressed video.

3. PROPOSED IMPLEMENTATION

Heart illnesses are the real sympathy toward many individuals. So, finding of the heart related issues and counteractive action of the same has at generally significance. The checking of electrocardiogram (ECG) flag is the typical test for recognizing issue of the heart. This paper demonstrated the utilization of partition and vanquish calculation for the examination of ECG waveform. Individuals with a heart related issues have the long record of ECGs for indicative purposes, which brings about the prerequisite of a lot of storage space. ECG pressure is a superior technique for minimize computational multifaceted nature as far as storage. Consequently, built up a mechanized determination framework for doctors particularly cardiologist for simple finding of ECG varieties and characterization of the ECG waveforms under ordinary and strange classes. By growing such a framework with pressure and reproduction capacity the memory lack issue additionally can be disposed of.

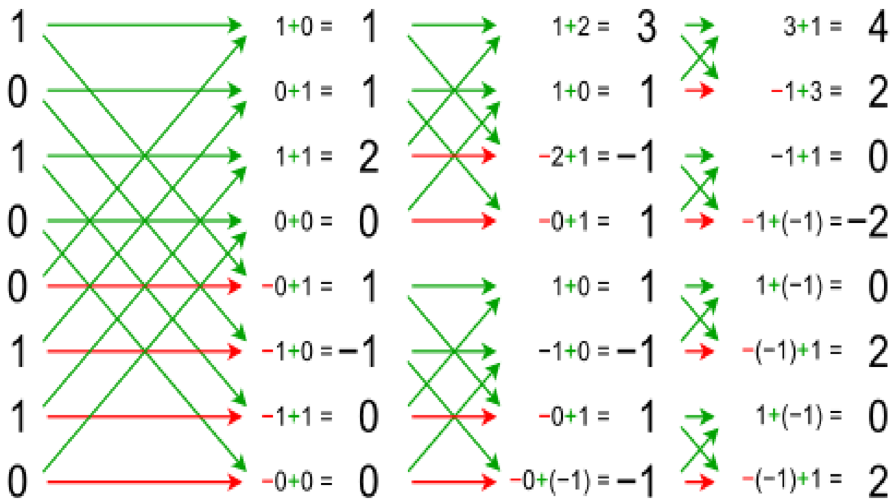

Fig. 1: Example of fast WHT using DCA.

The Discrete Walsh-Hadamard transform (WHT) is an orthogonal transformation that decomposes a signal into a set of orthogonal, rectangular waveforms called Walsh functions [8], [9]. The Hadamard transform take only the binary value +1 or -1. The direct and inverse DWHT pair for a signal x(t) of length Nare respectively expressed as follow:

$$y_n = \frac{1}{N}\sum_{i=0}^{N-1} x_i W\ AL(n,i), n = 1,2,\dots,N-1$$

$$x_i = \sum_{n=0}^{N-1} y_n W\ AL(n,i), i = 1,2,\dots,N-1$$

Where $x(n)$ and $y(n)$ are the original and reconstructed signals. WHTs are used in various applications such as filtering, power spectrum analysis, speech processing and bio-medical signals, characterizing non-linear signals, multiplexing, and coding in communications, logical design and analysis and solving non-linear differential equations. A divide and conquer algorithm (DCA) work by recursively breaking down a problem into two or more sub-problems of the same or related type, until these become simple enough to be solved directly. The solutions to the sub-problems are then combined to give a solution to the original problem. Fast Walsh Hadamard is a DCA that recursively breaks down a WHT of size N into two smaller WHTs of size$N/2$.This implementation follows the $2N \times 2N$ Hadamard matrix recursive definition.

$$H_N = \frac{1}{\sqrt{2}} \begin{bmatrix} H_{N-1} & H_{N-1} \\ H_{N-1} & H_{N-1} \end{bmatrix}$$

The normalization factors for each stage may be grouped together or even omitted. The sequency ordered, also known as Walsh ordered, fast Walsh–Hadamard transform, $FWHT_w$, is obtained by computing the $FWHT_h$ as above, and then rearranging the outputs.

Algorithm
Input ECG = O
Compressed ECG = Y
Reconstructed ECG = R

Step 1: Read an input ECG signal ‘O’ from MIT-BIH database

Step 2: Replicate it to create more data ‘Or’

Step 3: Add some random noise to the ‘Or’ with a variance of 0.1 to get the ‘X’

Step 4: Now, apply DCA to the ‘X’ to get the Walsh hadamard coefficients with lesser number of computations

Step 5: Consider only first 1024 coefficients out of 4096, which has most of the signal energy and store it in ‘Y’

Step 6: Now, reconstruct the ECG data using ‘Y’ by applying inverse DCA

Step 7: Finally, compare the ‘O’ and ‘R’ to observe the compression of ECG data in which the storing memory has been reduced from 32,678 bytes to 8200 bytes.

4. EXPERIMENTAL RESULTS

This section deals with the experimental analysis of proposed DCA algorithm to compress the ECG signal data which have been done in MATLAB environment. MATLAB is a high-level technical computing language that is used to develop signal processing algorithms. It has many advantages over conventional programming languages such as C, C++, JAVA, FORTAN, COBALT, VHDL and VERILOG. We have considered MIT-BIH ECG database for testing the proposed algorithm.

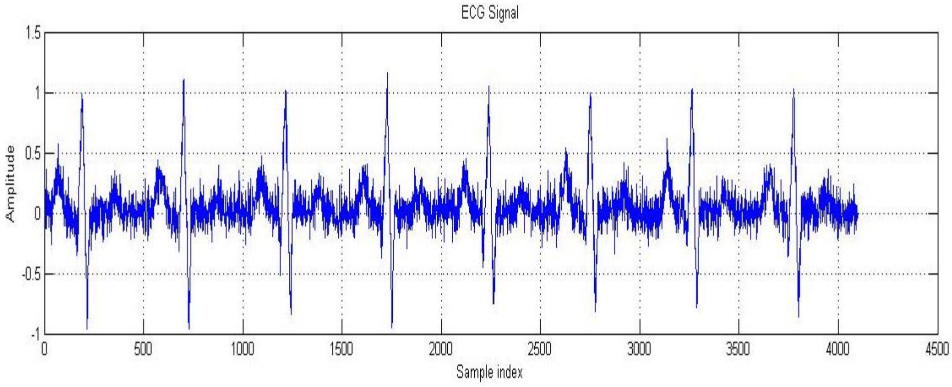

Fig. 2: Input ECG signal.

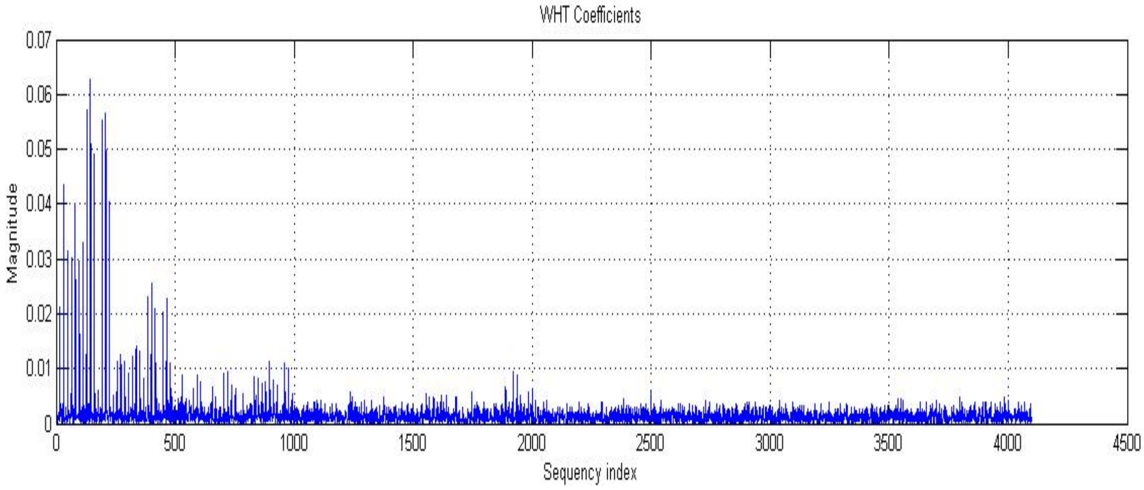

Fig. 3: Coefficients after applying DCA scheme.

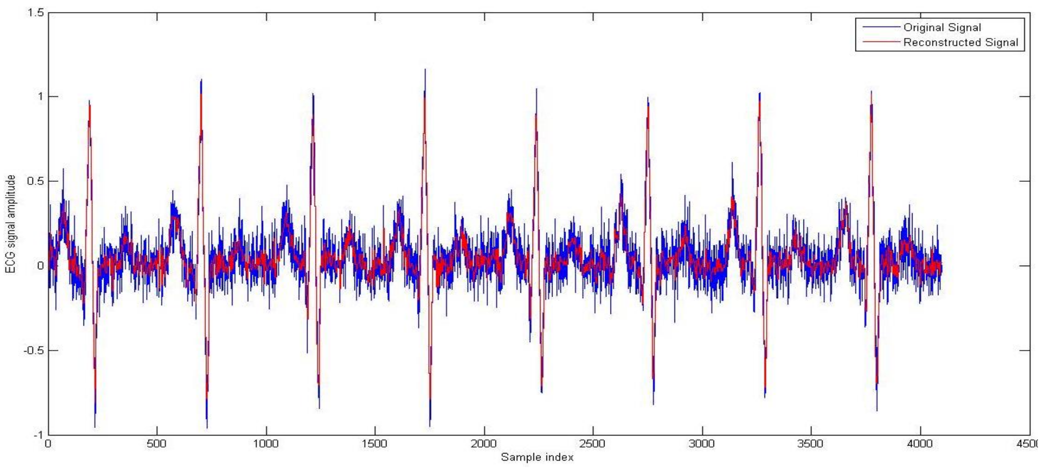

Fig. 4: Comparison of original and reconstructed signal using DCA scheme.

Variable Name	Bytes
Y	8200
X	32768

5. CONCLUSIONS

An efficient scheme for compression electro cardiac signal data has been implemented with reduced number of computations using DCA scheme. Proposed scheme performed excellent simulation results over conventional compression schemes in terms of storage in number of bytes.

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