A Novel Compression Framework for Electro Cardiac Signals

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Abstract. Electrocardiography (ECG) is a method of measuring cardiovascular electrical movement over a span of time using skin-situated electrodes. In patient surveillance, large volumes of ECG information must be preserved. So as long as we essential to track a patient heart working condition, we should have to save more facts. However, it is very expensive to storage, transmit in addition distribute bandwidth. A powerful compression strategy has been practical to solve this problem so that all the excellent scientifically important functionality can be conserved. We used the MIT-BIH ECG information base for ECG research.

Keywords: ECG data, Fourier transform, Fast Fourier Transform, DCT, DWT, Walsh hadamard transform and MIT-BIH ECG database

1. Introduction
The measurement of electrical heart action [1] checks how the heart functions. Persons with cardiac-related complications have a long background for diagnosable ECGs, so vast number of storage facilities are essential. Subsequently there is a requirement for a framework which contains ECG pressure indicators alongside ECG investigation [2]. ECG pressure is a superior technique for minimize computational many-sided quality as far as storage. Flag pressure in addition flag check-up have demand in many application areas mostly in biomedical sector [3]. ECG indications are varied for every individual. The ECG design acknowledgment is a standout amongst the utmost dependable coronary illness recognizable proof strategies. The cathodes linked to the body recognise the electrical move of the heart. Each and every terminal the ECG will record in addition store for a drawn out stretch of time. [5]. In this, QRS complex is most essential part which demonstrates the electrical depolarization of the ventricle muscles in the heart. The duration also 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 historical backdrop of heart diseases will constantly have to keep up a huge load of ECG reports while going to a specialist for meet. We will probably layout a structure which incorporates pressing factor of ECG for requesting average also odd classes of ECG indications. Digitalising the ECG banner will deal with the capacity problem besides it moreover will be reasonable when originates to sharing also 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 [4]. Through this data pressure method framework needs to accomplish greatest data volume lessening while protecting noteworthy data’s. The requirement for flag pressure in many applications those are required for transmission and storage. 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. For all intents and purposes proficient data pressure might be accomplished just with...
loss pressure techniques. On account of ECG flag pressure, the primary target is to accomplish less number by safeguarding the significant indicative in the recreated flag. There is an expanding interest for long haul persistent monitoring of a patient's ECG and action, which offers the chance to assess the execution of the cardiovascular framework [6].

2. Related Work
In past, explores have proposed change techniques, for example, Fast Fourier Transform, Discrete Cosine Transform [10] also Discrete Wavelet Transform. FFT has the preferred standpoint that it lessens the quantity of calculations. FFT is utilized for the ECG flag pressure alongside zero associating limitation. For the most part ECG flag decay is thought to be time differing because of some heart variations from the norm. By utilizing general FFT conditions the Fourier arrangement coefficients are computed, and this procedure must be performed on each recognized cycle. These Fourier arrangement coefficients are utilized to incorporate the first flag [11]. The block chart demonstrates the pressure and reproduction arranges in the method. The primary stage is the change computation. At that point apply edge condition on change coefficients on the premise of vitality pressing effectiveness of coefficients [7], that makes settled number of edge esteem is set to zero. Versatile thresholding settled thresholding or edge set by physically is likewise embraced. This esteem can be picked by considering the most extreme estimation of coefficient. Next stage is applying uniform quantization on these coefficients. The progression estimate esteem is acquired from the most extreme and minimum estimation of the flag framework. By setting step estimate the quantization levels are made and relating quantization tables are made to reproduce the first flag. The quantized data contains repetitive data which causes wastage of space.

With a specific end goal to defeat this disadvantage entropy encoding strategy known as Huffman coding is utilized [13]. The heart beat sensor TCRT1000 is used for continuous monitoring the heart beats of a user per minute. The blood pressure is the quantity of beats per minute measured and the heart rate measured. In this stage the probabilities of event of the symbol in the flag are figured and in view of this esteem make another Table. [12] This Table esteem gives the packed adaptation of ECG flag. For the characterization and investigation handle the table must save the information's with respect to the R peak and RR interval. From this, it is straightforwardly comprehending that quantized table is subject to the first ECG flag.

2.1. Fourier Transform
The sign can be breaking down more adequately in frequency area than the time space, in light of the fact that the qualities of a sign will be more in frequency space. One conceivable approach to change over or transform the sign from time to frequency space is Fourier transform (FT) [14].

FT is a methodology which separates the sign into various frequencies of sinusoids, and it is characterized as a scientific methodology for transforming the sign from time space to frequency area. FT has a downside that it will work out for just stationary signs, which won't change with the time frame. Since, the FT connected for the whole flag however not portions of a sign, on the off chance that we consider non-stationary sign the sign will fluctuate with the time frame, which couldn't be transformed by FT. also, one more downside that we have with the FT is we can't say that at what time the specific occasion will has happened.

2.2. Short-Time Fourier analysis
To adjust the inadequacy in FT, Dennis Gabor in 1946 presented another technique called windowing, which can be connected to the sign to investigate a little area of a sign. This adjustment has been called as the Short-Time Fourier Transform (STFT)[15], in which the sign will be mapped into time and frequency information. In STFT, the window is altered. In this way, we this window won't change with the time of the sign i.e., for both tight resolution and wide resolution. Also, we can't anticipate the frequency content at every time interm segment.
2.3. Discrete Cosine Transform

DCT was one of the processes used to disintegrate a host signal into many frequency ranges. This made it much simpler to compact the meta data where even the data can be translated to a spatial domain and broken into 8x8 blocks. The DCT is given in two dimensions

\[
C(0,0) = \frac{1}{N} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) \\
C(u,v) = \frac{1}{2N^2} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) \ast [\cos(2x + 1)u\pi] \ast [\cos(2y + 1)v\pi]
\]

Where, \( u = 0,1,2,\ldots,M-1 \), \( v = 0,1,2,\ldots,N-1 \) and \( j = \sqrt{-1} \). The inverse DCT (IDCT) is given by

\[
f(x,y) = \frac{1}{N} C(0,0) + \frac{1}{2N^2} \sum_{u=0}^{M-1} \sum_{v=0}^{N-1} C(u,v) \ast [\cos(2x + 1)u\pi] \ast [\cos(2y + 1)v\pi]
\]

2.4. Wavelet Analysis

A wavelet technique i.e., variable windowing has been introduced to overcome the STFT drawbacks. Wavelet analysis makes the use of time periods, how we want detailed info with less frequencies, and shorter areas wherever we want knowledge with higher frequencies.

![Figure 1. Wavelet Decomposition Tree](image)

In above Figure 1, it is shown that the decomposition of input using wavelet transform and how the analysis of transformation will apply to get the frequency information of input signal. We can observe that it shows more number of features. Wavelet is also called as multi resolution analysis (MRA).

3. Proposed Methodology

![Figure 2. Sample of Fast WHT using DCA](image)

Heart ailments are the genuine compassion for some people. So, discovery of the heart related issues and neutralizing activity of the equivalent has at by and large importance. The inspection of electrocardiogram banner is the normal test for perceiving issue of the heart. This paper exhibited the use of parcel besides vanquish computation for the assessment of ECG waveform. People with a heart connected issue get a long history of ECG for controlling reasons, which implies that much stockpiling
limit are required. ECG pressure is an unrivaled strategy for limit computational complex nature to the extent stockpiling. Thus, developed an automated assurance structure for specialists especially cardiologist for straightforward finding of ECG assortments also portrayal of the ECG wave forms under conventional also bizarre classes. By developing such a structure with pressing factor then multiplication limit the memory need issue also can be discarded.

The Walsh-Hadamard Discrete Transform (WWT) is an orthological transition that breaks down a signal into a group of linear analogous wavelengths called Walsh Components [8]. Only binary value +1 or -1 is used to convert Hadamard. The forward and reverse DWHT pair is described as follows for a signal X(t) of length N, In above Figure 2.

\[ y_n = \frac{1}{\sqrt{N}} \sum_{i=0}^{N-1} x_i W AL(n, i), n = 1, 2, \ldots, N - 1 \]  
\[ x_i = \sum_{n=0}^{N-1} y_n W AL(n, i), i = 1, 2, \ldots, N - 1 \]  

Where \( x(n) \) besides \( y(n) \) are the original and reconstructed signals. Characterizing non-linear signals, multiplexing also coding in communications, rational design in addition analysis besides solving non-linear differential equations. A division and conquer algorithm (DCA) [9] operate by the remedial breakup of an issue into 2 or more subsets or same similar kind, since these are relatively easy for immediate resolution. The answer to the issues eventually is mixed in order to answer the initial issue. Fast Walshhadamard is a DCA that recursively breaks down a WHT of size N into 2 smaller WHTs of sizeN/2. This implementation follows the 2N × 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 series ordered, also called Walsh ordered, is quickly converted into Walsh – Hadamard, FWHTw and then rearranged by measuring the FWHTh as above. The normalisation variables for each point can be placed together or even ignored.

### Algorithm

| Input Signal of ECG = O |
| Compressed Signal of ECG = Y |
| Reconstructed Signal of ECG = R |

Step1: Read an input ECG ‘O’ from MIT-BIH
Step2: Duplicate it to make more data ‘Or’
Step3: Improve some random noise to the ‘Or’ through a variance of 0.1 to get the ‘X’
Step4: Now, apply DCA to the ‘X’ to get the Walsh hadamard coefficients by smaller number of computations
Step5: Study only first 1024 coefficients out of 4096, which has utmost of the signal energy also supply it in ‘Y’
Step6: Now, rebuild the ECG using ‘Y’ by applying inverse DCA
Step7: In conclusion, comparation the ‘O’ also ‘R’ to perceive the density of ECG information in which the storing memory has been summary from 32,678 bytes - 8200 bytes.

### 4. Experimental Results

This part manages the test investigation of planned DCA calculation to pack the ECG indication information which have been complete in MATLAB climate. MATLAB is a general specialized registering language that is utilized to create signal handling calculations. It has numerous benefits over traditional programming dialects like JAVA, COBALT, C, VHDL, C++, FORTAN also VERILOG. We have careful MIT-BIH ECG information base for challenging the planned calculation. Unique. ECG
indication information has been appeared in Figure 3. Yield of DCA conspire has been appeared in Figure 4, where the vast majority of the sign energy has been sequenced in coefficients under 1100. The Figure 5 it has shown that the remade signal contrasted and the first sign in the wake of applying backwards DCA plot by thinking about just 1024 coefficients, which demonstrates that the sign will be packed very nearly multiple times to the first ECG indication information that implies the pressure proportion is 4:1.

![Figure 3. The Waveform of Input ECG](image)

![Figure 4: Coefficients afterwards spread on DCA](image)

![Figure 5. Evaluation of original also reconstructed signal with DCA](image)

| Variable Name | Bytes |
|---------------|-------|
| Y             | 8200  |
| X             | 32768 |
5. Conclusion
An efficient scheme for compression electro cardiac signal information has been implemented with compact number of computations using DCA system. Proposed system achieved outstanding simulation outcomes concluded conventional compression system in terms of storing in number of bytes.

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