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DESIGN OF OPTIMIZED COMPRESSION ALGORITHM FOR ENERGY EFFICIENT ECG BIOSENSORS

R.Ganesan and S.Rajalakshmi
Assistant Professor and M . E, Embe dded System Technologies
TIFAC -CORE i n Pervasive Computing Technologies
Velammal Engineering College,
Chennai –600066, India.

ABSTRACT — In digital signal processing, data compression process involves encoding information using fewer bits than the original representation by removing the redundant information from the data so that it can be stored to reduce the storage size, transmission bandwidth and time. For telemedicine, signal archiving and transmission over communication channel effective approach to reduce data communication in network is to compress the information before it is transmitted. Wireless body sensor or area networks enabled electrocardiogram (ECG) biosensors are a novel solution for patient centered remote cardiac diagnosis and treatment. Electrocardiogram (ECG) data compression reduces the storage requirements thus developing a more efficient tele - cardiology system for cardiac analysis and diagnosis. In a wireless ECG biosensor, the power is consumed by three components such as sensing, computing and communication. Data communication is the main factor which drains the energy receives of the node. The communication consumes more than 65% of the total energy. To preserve the energy due to communication by efficient data compression, different schemes have been proposed aiming very low power. This paper is focused on developing a low complexity and efficient algorithm which has the characteristics of high compression ratio, less compression time by performing data compression using multi-wavelet transform and Set Partitioning in Hierarchical Tress (S PIHT) encoding. The performance is evaluated in terms of compression ratio(CR), percentage root mean square difference(PRD) .In this work the proposed solution have to be modeled and simulated using MATLAB. The proposed scheme is evaluated using the ECG records of Massachusetts Institute of Technology- Beth Israel Hospital (MIT/BIH) ECG database and results in terms of compression ratio, signal recovery quality are evaluated.

KEYWORDS - Data Compression, ECG, Multi-wavelet Trans form,SPIHT**.**

I.INTRODUCTION

CARDIOVASCULAR Diseases (CVDs) are the le a d in g root cause of death worldwide. According to a World Health Organization (WHO) report, about 17.3 million people died because of CVDs in 2008, accounting for 30% of total global deaths, and this number is expected to rise to 23 million in 2030[1]. However, many of these deaths can be avoided by early diagnosis and medication..In this a s p e c t ,electrocardiograms (ECG) were the most efficient and common way to diagnosis cardiovascular diseases. An

electrocardiogram (ECG) is simply a representation of the electrical activity of the heart muscle as it changes with time. Like other muscles, cardiac muscle contracts in response to electrical depolarization of the muscle cells. It is totality the sum of this electrical activity, when amplified and recorded for just a few seconds that we know as an ECG. The electrocardiogram (ECG) is an significant physiological signal for cardiac diagnosis. Traditional holter ECG monitor have made great contributions to the heart disease diagnosis by daily ECG logs. However, there still exist some limitations, such as non-real time, non-wireless, bulkiness, and low autonomy. Recently, wireless body sensor networks (WBSNs) are considered in widespread as a costly patient-centered and most efficient telecardiology solution to ambulatory ECG monitoring and recording.[2][8].

BSNs are playing an predominantly important role in the fields of medical treatments. BSNs are a kind of WSN which is formed by placing the sensors in the human body by placing it on body surface or around the body to measure the physiological parameters the main techniques it covers are sensors, data processing, and network communication. Its main purpose is to provide an integrated pervasive computing hardware, software, and wireless communication technology platform and also the transmission platform must be secured for transmission of medical data for healthcare system[3][9] and an essential condition for the future development of pervasive health care monitoring systems. The WBSN-enabled ECG bio -sensor could be integrated without any interruption into apatient's life and continually provide real-time heart state information.

However in real time applications the energy efficiency of WBSN enabled ECG biosensor an significant and a challenging issue. In a wireless ECG biosensor, the power is mainly consumed by three components: sensing, computing, and communication; the communication consumes more than65% of the total energy. A proper methodology of compressing the data before transmission can reduce the amount of transmitted data and it also can decrease the airtime over energy hungry wireless links, thus improving the sensor nodes energy efficiency [3]. After initiatory treatment of signals, sensor nodes generally do compression and encryption before sending it to abase station or sink node directly. Data compression can effectively reduce the amount of data transmission or data communication. the amount of data transmission. Since the memory module and data sending module consume ample of energy data compression can lower power consumption economically on BSN sensors by reducing information stored in memory and transmitted by the transceiver.

In body sensor network data compression can be achieved by classical data compression algorithms , such as source or entropy encoding, differential e n c o d i n g , a n d Huffman encoding. . The ECG data is compressed with an aim to storing it and later on decompressing or decoding it without any loss of medical information. Compression is a way to reduce or minimize the no. of bits in a frame but retaining its meaning by minimizing space, time to transmit and cost and thus It sultimate technique is to identify redundancy and eliminate it. The idea of representation is signal/information in lesser or fewer bits and any signal that contains some unimportant information data to be compressed . [4]A compressor can reduce the size of a file by deciding on which data is more frequent and allots it less bits than to less frequent data to save time when transmitting it and to save space when storing it . The design of data compression scheme therefore involves a compromise among various factors including the degree of compression, the amount of distortion introduced and the computational resources such as microcontroller or DSP required to compress and uncompress the data .Two types of Compression are a)Lossless compression refers to an compression

methodology for which the original uncompressed data or signal during decompression at the receiver side can be recovered exactly from the compressed stream. Lossless compression is an revers ible process [5] b) Lossy compression involves methods to eliminate unnecessary or redundant information or data. Lossy compression as it s name implies some amount of data maybe lost in the process. Lossy is an irreversible process. This motivates us to optimum the data transmission consumption in order to increase the node's lifetime. The main aim of any data compression technique is to achieve maximum data reduction while sustaining the significant signal morphology features upon reconstruction of the signal. ECG Data compression methods have been mainly d iv id e d into three categories:

1) Direct method: In direct method the actual signal Samples are analyzed in time domain, while using time domain data compression most of the signal will be lost ,hence for ECG signal the signal must be reconstructed as the original signal after compression without resulting in los s of information so that it can be used for cardiac diagnosis and treatment [6].

2) Transformational methods: In transform method first transform to the signal is applied and do spectral and energy distribution analysis of signals in frequency domain. In transformational method the data lost is less compared with direct data compression methods and are insensitive to noise present in ECG Signals.

3) Parameter Extraction Method: Parameter extraction method is an irreversible process in which the particular characteristics or the parameters of the ECG signals are retained.

This work consists of transformational technique where the ECG signal data compression is done. Lossless data compression is applied on ECG signal compression because in which the original uncompressed data is recovered exactly after the process of compression and without any loss of diagnostic data [7][8].

II.ARCHITECTURE

In this section, a proposed work for data of ECG is introduced. In order to overcome the existing problems, here it is proposed a multi-wavelet and SPIHT algorithm is used for getting the high compression ratio and very good signal recovery quality.

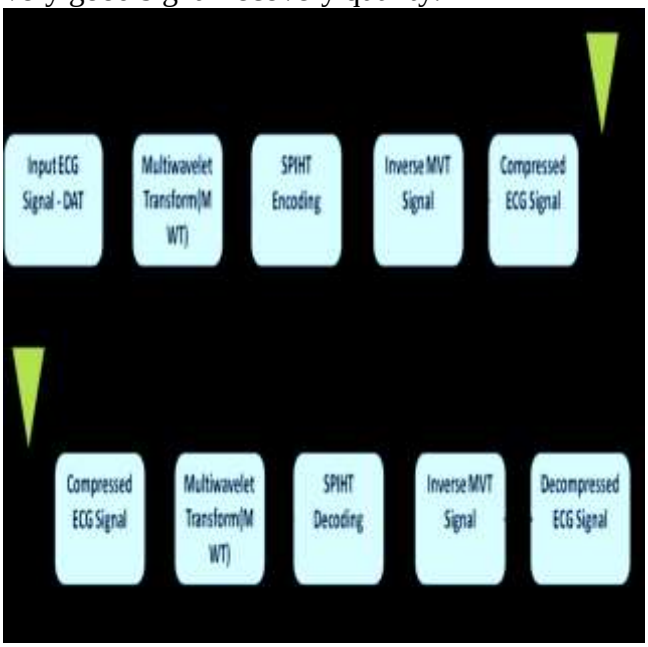

Fig1. Compression Scheme for energy efficient ECG biosensor

Figure 1 clearly depicts the proposed architecture for compression of ECG signal for energy efficient wireless ECG biosensor. The ECG signals from a database thus removing its mean and normalize the resulting meaner moved signal. In this work all ECG signals considered are extracted from MIT -BIH database. The ECG signal taken from database is done with preprocessing thus removing its artifacts. Choosing the correct filter is very important and in this paper tenth order butter worth low pass filter is chosen to remove the noise or artifacts such as baseline artifacts from the raw ECG signal. The choosing of wavelet determine the shape of the wavelet we used to performance our analysis. In the database ECG signal is represented in DAT extension. A DAT file extension represents a file that contains raw data. Most DAT files are not meant to be opened manually. The

test datasets are taken from the MITB I arrhythmia database. The datasets are in DAT format in the MIT-BIH database [9].

The preprocessed ECG signal is applied with multi wavelet transformation thus transforming the signal in time domain to represent in frequency domain because there presentation of signal in frequency domain gives without any loss of diagnostic information thus making it viable for cardiac diagnosis and treatment. Then the transformed data is encoded using SPIHT encoding. SPIHT stands for Set Partitioning in Hierarchical Trees (SPIHT) algorithm. It can effectively extract the significant coefficients in wave let domain representation. SPIHT utilizes inherent redundancy among wavelet coefficients and is especially suited for electrocardiogram (ECG) data compression, since The properties of SPIHT encoding were its fast encoding and decoding its efficiency and it is completely embedded and its significant characteristic of error correction.

SPIHT algorithm is easy to understand to implement too and thus it is more suitable of robust storage of data for patient centric medical applications .Thus the ECG signal data is compressed and represented in binary bits as zeros and ones and thus transmitted via wireless communication and received at the receiver side to the sink node or base station. Since ECG signal compress ion is implemented using lossless compression, it has an reversible property of doing decoding and inverse multi-wavelet transform at the receiver side[7]. The performance of the proposed work is evaluated in terms of performance metrics.

III.TRANSFORMATION METHODOLOGY

The filter banks used to implement wavelet transform which satisfies properties such as orthogonality, symmetry ,short support and higher approximation order filtrations simultaneously thus improves the performance of compression considerably. Unfortunately due to implementation constraint wavelets do not satisfy all the above three properties simultaneously. A new class of wavelets, called multi wavelets surpasses this problem. So, this paper analyses the performance of the multi-wavelet transform. Like wavelet transform, multi-wavelet transformation were also based on upon multi resolution analysis. Multi resolution analysis using wavelets comprises of one scaling function Φ(t) and one function Ω(t) for wavelet where as multi-wavelet transform comprises of many number of scaling function under one vector denoted as $\Phi(t) = [\Phi 1(t), \Phi 2(t) \ldots \Phi N(t)T$ and many wavelet function denoted by

$W(t) = [\Omega 1(t), \Omega 2(t) \ldots \Omega N(t)]\ T$

satisfying both matrix dilation Equation(1)and wavelet Equation(2).

$\Phi(t) = \Sigma H[k]\ \Phi(2t-k)$ (1)K

$W(t) = \Sigma G[k]\ \Phi(2t-k)$ (2)K

Multi wavelets decomposition produce two low pass sub bands and two high pass sub bands in each dimension. Wavelet transformation or decomposition gives out four sub bands after decomposition of one level, whereas in multi-wavelet transform sixteen sub bands results after first level of decomposition. Multi-wavelet transform system can simultaneously provide perfect reconstruction of signal while preserving length due to orthogonality of filters, good performance at the boundaries (via linear-phase symmetry),and a high order of approximation . Transform based compression schemes which generally comprises of three stages such as, transformation, quantization and coding are more popular in recent days because the transform de-correlate the spatially distributed energy into fewer data samples. For lossless compression it consist only two stages transformation and coding stages.

Multi-wavelet transform possess an orthogonal property and its advantages were its easier calculation and thus when we decompose some data and calculating zero level decomposition we get accurate values and scalar factor multiplication with other base function equals zero.

IV .ENCODING TECHNIQUE

SPIHT Stands for Set Partitioning in Hierarchical Trees (SPIHT) algorithm. It can effectively infuse the significant coefficients in wavelet domain or representation . SPIHT utilizes inherent redundancy among wavelet coefficients and is especially suited for electrocardiogram (ECG) data compression, signal denoising and images and compression of images. SPIHT algorithm has the advantages of encoding methodology called embedded code tree stream structure, high compression rate, low complexity and easy to implement.

SPIHT is a simple and efficient algorithm with many unique and desirable properties. SPIHT is a highly scalable coding algorithm that can work with very low memory in combination with the wavelet transform [11] and showed that its performance can be competitive with state of the art image coders, with a fraction of memory utilization property. To the best of our knowledge, our vital aim in this work is to first propose a detailed implementation of a low memory wavelet signal coder and a significant advantage by making a wavelet coder attractive both in terms of speed and memory needs.

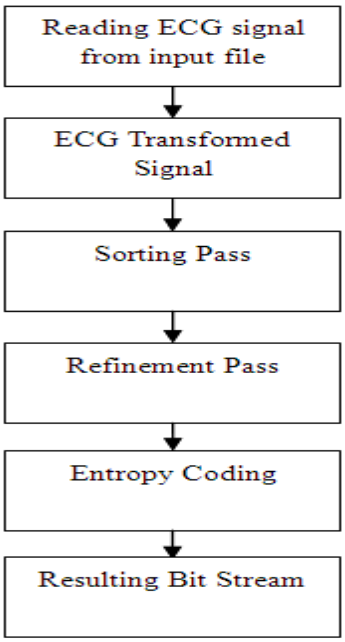

Fig2. Flow Chart of SPIHT Encoding

SPIHT is an embedded coding technique in which all encodings of the same signal at lesser bit rates are embedded at the beginning of the bit stream for the target bit rate.

Effectively, bits are ordered according to their importance. This type of coding is useful especially for a advanced transmission and transmission over a noisy wireless medium. Using an embedded code structure, an encoder or source code can terminate the encoding process at any point, thereby allowing a signal distortion parameter to be met as required. SPIHT encoding and decoding algorithm is base don concepts: Ordered bit plane progressive transmission, sorting algorithm and set partitioning spatial orientation trees. In SPIHT, this algorithm is identical for encoder and decoder continuously. In SPIHT the steps that were followed are given below:

Initialization: The original signal is decomposed into sub- bands then it finds the maximum iteration number.

Sorting Pass: Then second the method puts Multi wavelet transform coefficients and does encoding in the sign of its significant coefficients .

Refinement Pass: In the third step the significant coefficients that can be found in the sorting pass were put into the third step called refinement pass that uses two bits to exactly reconstruct the value that will be approaching to real value. The initialization, sorting pass and refinement pass steps are iterative, and then iteration decreases the threshold (Tn) and the reconstructive value (Rn-Rn-1/2) asa fourth Step, the encoding bits access entropy coding and then transmit or store the bit. The result is in the form of bitstream.

V. IMPLEM ENTATION AND RESULTS

The wavelet analysis of an ECG signal is performed using MATLAB software. MATLAB is dynamic high performance; interactive system which

allows in many technical computing problems especially in communications .The MATLAB software is provided with special wavelet toolbox. Thus the wavelet toolbox provides the tools for the analysis and synthesis of signals and wavelet packets within the MATLAB domain. All ECG datasets are taken from MIT- BIH arrhythmia Database directory set and Physionet database [12].

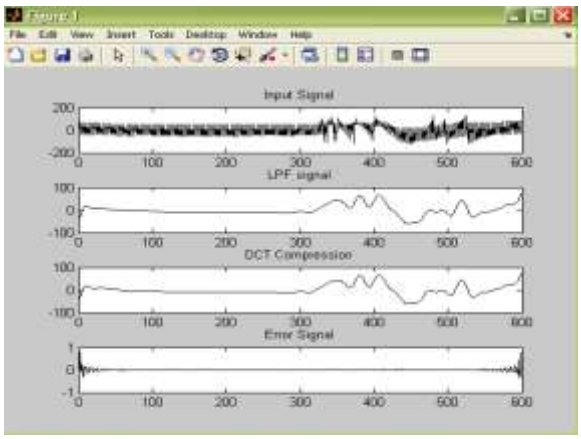

Fig 3. Plotting the ECG signal From DAT file values

Datasets	CR	PRD
200	67	0.31
100	61	0.34
101	53.5	0.35
102	55.8	0.28

Table 1.Shows CR and PRD of DCT

Discrete cosine transform technique of ECG data compression is done and the result is implemented using ECG datasets taken from MIT-BIH database.

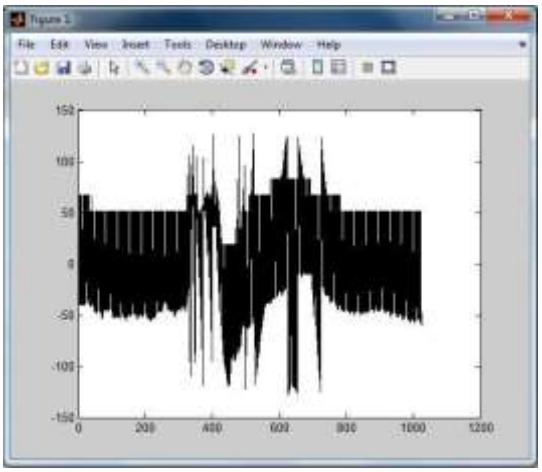

Fig 3.Data compression using Discrete Cosine Transform

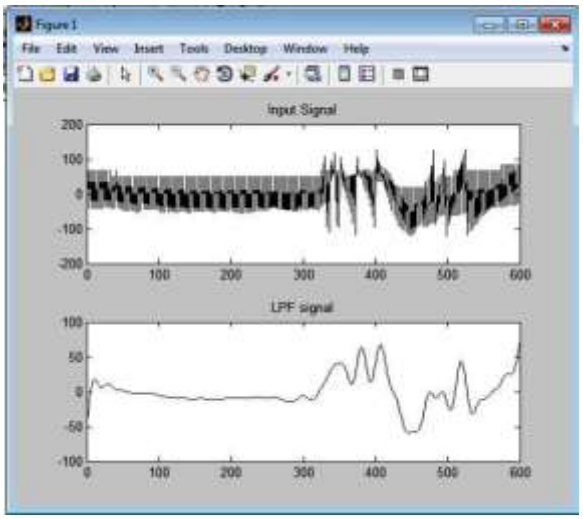

Fig 4.Importing Data Set and Performing Filtering on ECG Signal

VI.CONCLUSION AND FUTURE WORK

The first stage in data compression of ECG signal is to load a raw ECG signal into MATLAB software is done and the artifacts were removed using butter worth low pass filter. Thus the preprocessed signal can be taken to implement the proposed algorithm and evaluating its performance in terms of Compression ratio(CR),percentage root-mean square difference (PRD) and signal to noise ratio (SNR).

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