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**Title: Analysis of ECG Signal Using Some New Techniques**

## ABSTRACT

In this modern era of Information Technology, creation of database is essential for storing, retrieving or processing of any kind of information regarding any field. A patient with an organic heart disorder may have a normal ECG while a purely normal person may have nonspecific electrocardiographic abnormalities. Therefore, a further analysis of ECG records should be done to get a more specific observation and detection of cardiac abnormalities.

Electrocardiogram (ECG) obtained by noninvasive technique (does not involve puncturing the skin) is a harmless, safe and quick method of cardiovascular diagnosis. The accurate content of information extracted from recording require proper characterization of waveform morphologies that needs better preservation of signals and higher attenuation of noise. Wavelet transform has proved to be a useful tool for nonstationary signal analysis. Wavelets provide a flexible prototyping environment that comes with fast computational algorithms.

The objective of the thesis involves analysis, detection and compression of ECG signals. Noise reduction in ECG signals is one of the main problems, which comes along during analysis of electrical activity of the heart. The most troublesome noise sources contain frequency components within the ECG spectrum, due to the electrical activity of muscles and instability of electrode skin contact. The noise in ECG signal may occur like the myocardial infraction conduction, defects and arrhythmia. Such type of noises are difficult to remove, out of all noises using typical filtering procedures. Efficient analytical tool which allows to increase signal to noise ratio is a technique of averaging of cardiac cycles. In such signals, noise reduction is only possible using more advanced signal processing methods such as wavelet denoising technique. The recognition and analysis of ECG signal is not easy, as the magnitude of the signal is very low and noise may dominate the actual signal. Therefore, it is important to process the ECG signal to de-noise it and extract the desired signal shape. Many tools, methods and algorithms are employed for denoising the ECG signals. In the present studies wavelet transform is used for denoising the ECG signal. The ability of a wavelet to suppress a polynomial depends on a crucial mathematical characteristic of the wavelet, called its number of vanishing moments.

Thresholding involves the reduction or complete removal of selected wavelet coefficients in order to separate out the noise within the signal. The thresholding method, used in wavelet based denoising technique distinguishes between the insignificant coefficients likely due to crosstalk noise and the significant coefficients consisting of important signal components. Different threshold methods viz. sqtwolog, heursure and minimax, are applied with DWT on ECG signal denoising and among these heursure gives better SNR and also it produces smooth denoised signal and without changing the details of the signal.

The data is taken from MIT-BIH Arrhythmia database (‘100.dat’) for testing purpose. Each record consists of dual channel ECG data and is around 30 min long. The ECG signal is sampled at a rate of 360 Hz with 11 bit resolution over a 10mV range to obtain high SNR and number of QRS complexes from sym4 wavelet filter. This results in less time consuming analysis for a long time ECG signal.

The compression of ECG signals is desirable for two reasons: economic use of storage space for data and reduction of the data transmission rate for compatibility with telephone lines, may save a crucial time.If efficient compression methods are utilized, memory requirements may drastically fall to make the solid state high quality Hotler device commercially viable. For the ECG signal compression algorithms, the aim is to achieve a minimum information rate, while retaining the relevant diagnostic information in the reconstructed signal.

In this regard, we have carried out a comparative study based on the approach of Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT), Discrete Cosine Transform (DCT) and Wavelet Transform (WT). Different ECG signals are tested from the MIT-BIH arrhythmia database using MATLAB software. The experimental results are obtained for Percent Root Mean Square Difference (PRD), Signal to Noise ratio (SNR) and Compression ratio (CR). The result of ECG signal compression shows better compression performance in DWT compared to DFT, FFT and DCT.

Therefore, the DWT is a technique used to choose optimal wavelets for electrocardiogram (ECG) signal. Various criteria were used to evaluate the fidelity of the reconstruction. The Percent Root Difference (PRD) has been widely used in the literature as the principal error criterion. During the process of recording, the ECG wave suffers from several noise and interferences. These signals have been filtered using various wavelet filters. The use of filters improves signal quality. Three more criteria are used, namely signal to noise ratio (SNR), percent root difference (PRD without mean and PRD with mean) and compression ratio (CR).The best results have been obtained with the Sym20 dictionary.

Discrete wavelet transform (DWT) for a 2-D array can be derived from 1-D DWT. The easiest way for obtaining scaling and wavelet function for two dimensional is by multiplying two 1-D functions. A typical 2-D DWT, used in image compression, will generate the hierarchical pyramid structure. The wavelet coefficients can be organized as a set of trees for image coding. Every coefficient at a given resolution level can be related to a set of coefficients of the same orientation at the next higher resolution level.

Our ultimate goal is to develop an efficient architecture that can compress ECG data for which, there should be a novel approach of compressing the ECG signal. For that, we design DA-DWT based architecture for the complex computation. DA-DWT is used for reducing the complex computations, which can increase the speed and throughput as well. Proposed architecture is based on the principles of pipelining and parallelism to obtain the optimal speed and throughput. Architecture is simple, modular and cascadable for computing a DA-DWT. This technique is faster when the ROM table in on chip memory and memory size is reduced by splitting ROM table. The description and functionalities of the design have been modeled by Verilog HDL. The simulation and synthesis methodology are used to target it on Virtex-II Pro FPGA (xc4v1x25-12sf363) that consumes 6% resources of FPGA and shows the clock frequency 310.207 MHz by DA-DWT using Sym20. Experiments on selected records from MIT-BIH arrhythmia database revealed that the proposed design is significantly more efficient. Its application in the field of telemedicine.

The contribution presents the use of wavelet transform for a given ECG signal denoising, feature extraction, signal compression and its implementation on FPGA. However, our work also opens a wide range of applications in e-health.