

Design of FIR Filter Using Discrete Wavelet Transform for ECG Compression

Jeya Shenbagavalli.J¹, M.Ashok Kumar²

PG Scholar, Department of ECE, Adhiyamaan College of Engineering, Hosur, Tamilnadu, India¹

Asst. Professor, Department of ECE, Adhiyamaan College of Engineering, Hosur, Tamilnadu, India²

ABSTRACT: Transmission techniques of biomedical signals through communication channels are recently an important issue in many applications related to clinical practice. These techniques can allow experts to make a remote assessment of the informations carried out by the signals, in a very cost-effective way. Unlike the classical works based on off-line mode, the current work allows the real-time processing of the ECG signal to reduce the redundant information. A model is developed for a fixed-point convolution scheme which has a good performance in relation to the throughput, the latency, the maximum frequency of operation and the quality of the compressed signal. The quantization of the coefficients of the filters and the selected fixed-threshold give a low error in relation to clinical applications.

KEYWORDS: DWT, FIR Filter, ECG, Simulation.

I. INTRODUCTION

The “Electrocardiogram” (ECG) is a remarkable tool for diagnosis of heart diseases. The volume of ECG datum produced by monitoring systems may be quite large over a long period of time and ECG data compression is often needed for efficient storage of such data. Similarly, when ECG data need to be transmitted for telemedicine applications, data compression needs to be utilized for efficient transmission. While ECG systems are found primarily in hospitals, they find use in many other locals also. ECG systems are used by paramedic responding to accident scenes in emergency vehicles. They are also used by clinicians at remote sites. Certain military and/or space missions also employ ECG.

A growing area of use for ECG is the 24-hour holters that are leased by consumers. These portable ECG devices record and store the data for the frequent check by a doctor.

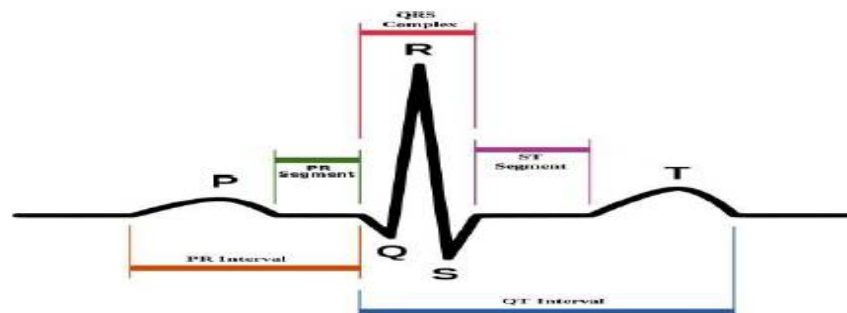


Fig.1.Diagram of ECG Cycle

II. ECG SIGNAL COMPRESSION

ECG compression techniques can be categorized into: direct time domain techniques, transformed frequency-domain techniques and parameters optimization techniques.

2.1 Direct Signal Compression Technique

A direct method performs the compression is directly done on the ECG signal. These are also called time domain techniques. To get a better performance time domain compression algorithm, intelligent sample selection method should be used. The original signals are reconstructed by an inverse process, often by connecting straight lines between the extracted samples. The key to a better and successful algorithm is the development of a better rule for determining the most significant samples.

2.2 Transformed ECG Compression Technique

Transform method, converts the time domain signal to the frequency domain or other domains and analyzes the energy distribution. These methods mainly utilizes the spectral and energy distributions of the signal by means of some transforms, and properly encoding the transformed outputs.

Signal reconstruction is achieved by applying an inverse transformation process. This category includes different transform techniques such as the Karhunen–Loeve transform, Fourier transform, Cosine transform, sub band-techniques, vector quantization (VQ), and more recently the wavelet transform. Wavelet technique is the obvious choice for ECG signal compression because of its localized and non-stationary property and the well-proven ability of wavelets to see through signals at different resolutions. The main task in wavelet analysis decomposition and reconstruction) is to find a good analyzing function (mother wavelet) to perform an optimal decomposition.

2.3 Optimization of ECG Compression Technique

Optimization method minimizes the reconstruction error given a bound on the number of samples to be extracted or the quality of the reconstructed signal to be achieved. The ECG signal is compressed by extracting the signal samples that, after interpolation, will best represent the original signal given an upper bound on their number. The aim is to present ECG compression technique that achieves maximum data volume reduction while preserving the significant signal morphology features upon reconstruction.

III. DISCRETE WAVELET TRANSFORM

The wavelet transform (WT) can be regarded as a mathematical function that cuts up data into components of different frequencies and then studies each component with a resolution matched to its scale. A signal at a large scale means that it has been smoothed strongly, thus leaving only global properties. In contrast, a small-scale signal corresponds to less smoothing and maintains more local properties. The WT is similar to the Short-Time Fourier Transform (STFT) but they differ in their time-frequency representations. By processing data with different window widths and at variable scales, the WT overcomes the limitation of STFT whose time-frequency resolutions are fixed over the entire time-frequency plane. More specifically, the WT processes data on a variable time-frequency plane (a time-scale plane) that matches progressively the lower frequency components to coarser time resolutions and the high-frequency components to finer time resolutions, thus achieving a multiresolution analysis.

Filters are one of the most widely used signal processing functions. Wavelets can be realized by iteration of filters with rescaling. The resolution of the signal, which is a measure of the amount of detail information in the signal, is determined by the filtering operations, and the scale is determined by upsampling and downsampling (subsampling) operations. The DWT is computed by successive lowpass and highpass filtering of the discrete time-domain signal.

In our approach, wavelet transform and inverse wavelet transform were used. Since there are a huge number of wavelet families having several different wavelets having high number of vanishing moments and capable of representing complex polynomials, it was not difficult to find a wavelet which was similar to the signal being processed. When transformed with the similar wavelet, the disturbances caused in the original signal were minimized which reduced the overhead. In DWT, the most prominent information in the signal appears in high amplitudes and the less prominent information appears in very low amplitudes. Data compression can be achieved by discarding these low amplitudes. The wavelet transforms enables high compression ratios with good quality of reconstruction.

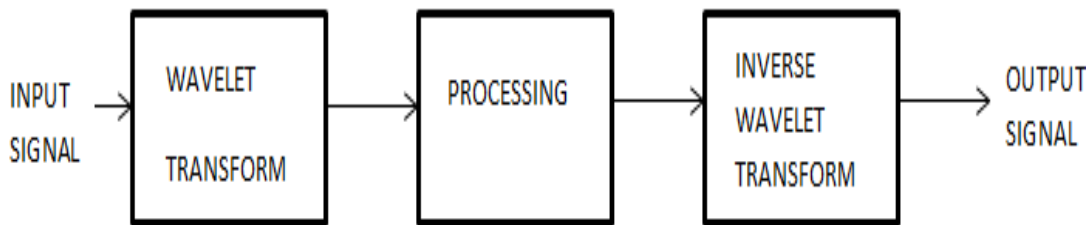


Fig.2. Signal Processing applications using Wavelet Transform

Fig.2 shows the general steps followed in a signal processing application. Processing may involve compression, encoding, denoising etc. The processed signal is either stored or transmitted. For most compression applications, processing involves quantization and entropy coding to yield a compressed image. During this process, all the wavelet coefficients that are below a chosen threshold are discarded. These discarded coefficients are replaced with zeros during reconstruction at the other end. To reconstruct the signal, the entropy coding is decoded, then quantized and then finally Inverse Wavelet Transformed.

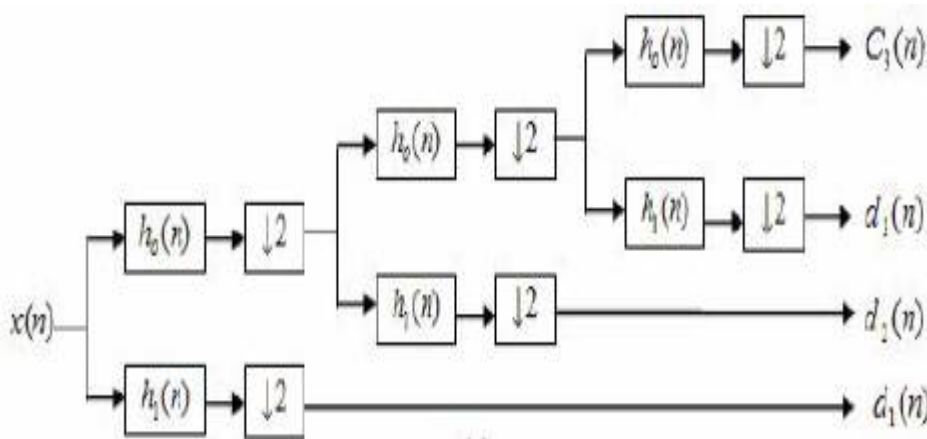
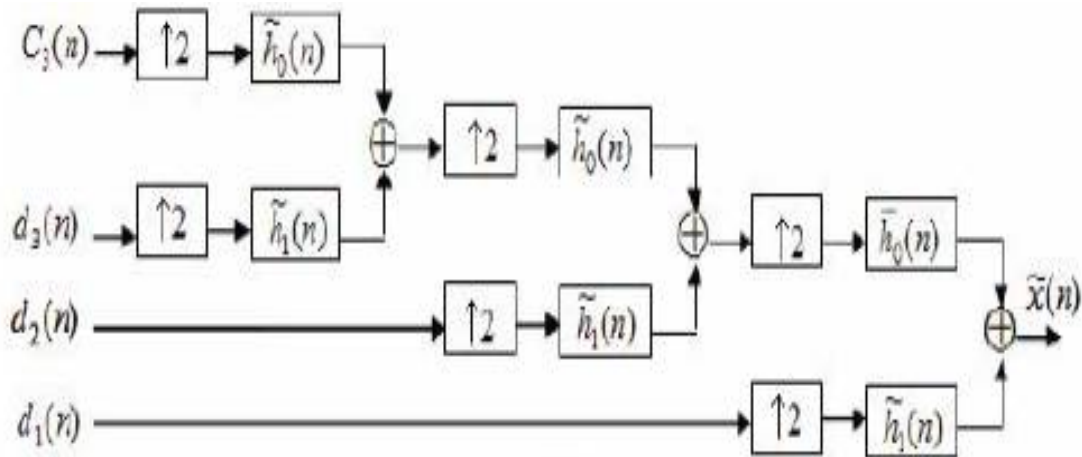


Fig.3. A three-level two-channel iterative filter bank (a) forward DWT



(b) inverse DWT

A generic flow of FIR filter design and implementation can be divided into three stages: finding filter order and coefficients, coefficient quantization, and hardware optimization, as In the first stage, the filter order and the corresponding coefficients of infinite precision are determined to satisfy the specification of the frequency response. Then, the coefficients are quantized to finite bit accuracy. Finally, various optimization approaches such as CSE are used to minimize the area cost of hardware implementations. Most prior FIR filter implementations focus on the hardware optimization stage. After FIR filter process, the output signals have larger bitwidth due to bitwidth expansion after multiplications. In many experimental situations, only partial bits of the full-precision outputs are needed.

3.1. FACTORS IDENTIFICATION

- Improved version by adopting the non uniform quantization.
- Coefficient optimization.
- Possible to reduce the delay by adding pipeline registers.
- Speed performance for mobile applications where area and power are important is considered.
- Possible Design Considerations.

IV. CONCLUSION

Wavelet transform decomposes a signal into a set of basis functions. These basis functions are called wavelets. It produces few coefficients, and the user does not have to worry about losing energy during the transform process or its inverse. DWT is faster and maps quickly to the sub-band coding of signals. DWT coefficients are based on amplitude and location of the signal, we can separate much of the noise from the signal easily. Wavelet technique is the obvious choice for ECG signal compression because of its localized and non-stationary property and the well-proven ability of wavelets to see through signals at different resolutions. The wavelet decomposition splits the analyzing signal into average and detail coefficients, using finite impulse response digital filters. The Modelsim SE 6.4 will be used for simulation and this must be done in VHDL language. The latency, the throughput, increase the compression, and decrease the distortion in the reconstructed signal is done by Xilinx.

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