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ALGORITHM AND VLSI ARCHITECTURE DESIGN OF LOW POWER SPIHT DECODER FOR mHealth APPLICATIONS

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Abstract

This paper presents a 1D encoding system for biological signals, with the goals of metadata embedding and confidentiality. The ECG signal is compressed and then reconstructed. Mobile health (m-health) storage, transmission, and access to diagnostic tests are prioritized in the design. Existing SPIHT encoding systems, on the other hand, were developed with the processing of pictures and videos in mind. Both designs have serious limitations when used to mobile ECG applications, such as a lack of available memory and the need for complicated sorting algorithms. Based on our revised SPIHT coding study, we combined three search operations into a single phase, using flags and bit controls to decrease memory requirements and code complexity. Therefore, it is necessary to provide a real-time architecture for ECG applications on mobile devices. First, we propose an SPIHT coding algorithm that uses multiple types of state registry files in order to meet real-time and performance design goals, overcoming the drawbacks of previous SPIHT algorithms such as slow encoding speed and complex hardware architectures. Second, the suggested technique is utilized to inform a low-power, high-efficiency SPIHT design that is implemented using a highly pipeline, very large-scale integration (VLSI) architecture.

Keywords: SPIHT Decoder, ECG Compression, wavelet, biomedical.

INTRODUCTION

There is a need for health evaluations to evolve, in the spirit of mobile health, into a new patient-centered health paradigm made possible by ICT. Physiological signals (ECG, EEG) are at the heart of these assessments, but more data is needed to fully understand its clinical importance and use it for early diagnosis, consistent follow-up, and individualized therapy [3]. Three lists of pixel addresses and sets to be processed form the backbone of classic SPIHT. The list has to be stored in a lot of dynamic memory. More coefficients are needed for SPIHT with a larger number of list nodes as the data rate grows. Complex memory management makes it hard to comprehend and may reduce performance for real-time applications. Several options for making the SPIHT algorithm use less memory have been studied. Memory use is minimized when the SPIHT algorithm is implemented using the no-list SPIHT (NLS) technique. However, NLS does not allow for the concurrent processing of coefficients, leading to a low throughput. The complexity of SPIHT has been reduced in the new approach by using a 1D address and less intensive scanning. In order to avoid the need for a register, low-memory zero-tree coding employs a top-bit coefficient status technique. Better performance is guaranteed by encoding more crucial low-frequency band coefficients in listless modified SPIHT [1].

As the number of health-related apps for smartphones continues to grow, mobile health has emerged as a prime area for exploring how well social insurance can be integrated with mobile technology. ECG signal analysis is a top and rapidly growing mobile health application. The human heart is a three-dimensional structure, and throughout its development phase, the characteristic current sign is measured at several approximations called leads. The ECG should capture multi-lead estimation data [2].

An excellent wavelet coding method called hierarchical tree partitioning (SPIHT) has recently been proposed for ECG compression [14, 15]. SPIHT's continuous coding function, in which signal quality may be improved progressively with a higher compressed bit rate, is an intriguing feature. Once the target quality has been reached, the encoding process may be terminated. However, SPIHT-based ECG compression technology integration has not been addressed in the literature [4]. Compared to EZW and DCT, the SPIHT implementation in WMSN is preferable because to its greater compression ratio, decreased computational complexity, lower power consumption, and more resilient application. SPIHT generates highly small output bit flow without the need of an entropy encoder, which minimizes computational complexity and improves data transmission efficiency [3]. [5].

Large amounts of data generated by ECG monitoring devices need compression for effective processing, storage, and transmission. Many wavelet algorithms based on transformations have been proposed as a means of reducing reconstruction errors in conjunction with lossy data compression strategies.

These strategies provide high CRs without requiring rebuilt diagnostic functions from the signals themselves. When it comes to diagnostics, lossless compression approaches are preferred over applications that alter the signal [6].

Methods

2.1 Aim, design and setting of the study

In order to compress and reconstruct the ECG data, an SPIHT decoder is developed. The software makes use of the dataset's ECG signals across a number of categories.

Both synthetic and natural waveforms were used in the recordings.

The electrocardiogram (ECG) signal undergoes encoding and decoding processes. Bit error rate, symbol-to-noise ratio, and other metrics are computed and tabulated.

Physionet.org is where we get our ECG readings. This database includes ECG recordings from many different types. The MIT Laboratory for Computational Physiology maintains a database of publicly accessible medical research data.

When it comes to developing efficient wavelet compression systems, SPIHT is an important area of study. The SPIHT initiatives are cutting edge. There are two main types of these models: List-oriented SPIHT

style, as well as SPIHT's non-list list-based design. The list-oriented SPIHT encoding technique incorporates two sorting and refining operations that rely on a three-pass structure to improve efficiency. The SPIHT system, which works with lists, needs a lot of space and processing power. It's really challenging hardware-wise, and the resulting performance is poor, to filter through and fine-tune the process.

Only video/image compression is appropriate, and the quality of the compressed ECG is not necessary. The SPIHT quality of the code is therefore sacrificed in favor of increased hardware speed, and the designs are based on the hardware architecture. The SPIHT encoder schemes are not list-based like the SPIHT architecture. Unfortunately, low-cost and power-constrained mobile devices cannot handle the buffer size of the transform wavelet decay layer and the picture size that the SPIHT requires [11].

SPIHT received a helpful technique to code wavelet coefficients for 2-D picture compression. The technique has been implemented on the ECG signal after being modified for case 1-D. This technique of compressing and calculating an electrocardiogram was far more efficient than its predecessors. The SPIHT algorithm wasn't the only thing that was great about it. Symmetric encoding, loss-free entropy coding compatibility, scalability, minimal complexity, and moderate memory usage are further features. Because of these features, the approach was extended to include 0(3D) and 4-D situations. Low-power, real-time ECG compression using very large-scale integration (VLSI) silicon. The ideas several layers of self-similarity, ordered bit spreading, and a magnitude-based structure for transformational coefficients generated by a fixed division algorithm are the main ideas SPIHT is built around. SPIHT is an algorithm. The most important data will always be sent to the decoder if the encoder follows these rules.

Using VLSI architecture shortened the design process and simplified the computations involved. Initialization, trial, and refining are the three phases of the original SPIHT technique for acceleration.

The procedure may be divided into three rounds of list refinement and organization. However, the no-list method is an exciting new avenue for study in SPIHT design. The SPIHT coder may be implemented without the need of a list thanks to the SPIHT non-list approach [10], which is simple and hardware-efficient. Unlike with video, the demands of electrocardiogram (ECG) quality-on-demand are not well-suited to plans that depend on technical reordering and synchronization to boost equipment speed. A non-listing SPIHT encoder was advocated over a rundown-based SPIHT strategy. Not only are the pricing and power of restricted mobile phones unacceptable, but the SPIHT blacklist also increases the cradle size along the wavelet shift lowering layer and the picture, which is problematic.

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4 Proposed SPIHT Decoding Algorithm

4.1 Transmitter Part

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The design time and computing complexity were both decreased by the use of VLSI architecture. There are three stages to the first SPIHT method for acceleration: initialization, trial, and refinement.

The process may be broken down into three iterations of list sorting and refinement. However, the no-list approach is a promising new direction for SPIHT design research. The SPIHT non-list technique is straightforward and hardware-efficient, allowing the SPIHT coder to be implemented without a list [10]. Plans that rely on technological reordering and coordination to enhance equipment speed are not optimal for quality-on-demand electrocardiogram (ECG) pressures but are well-suited for video pressures. When compared to an SPIHT plan based on a rundown, a non-listing SPIHT encoder was recommended. To make matters worse, the SPIHT blacklist expands the cradle size along the wavelet shift reducing layer and the image, neither of which are enough to satisfy the prices and power of constrained mobile phones [2].

For a conventional wavelet-based ECG compression scheme, there will be three steps:

1. discrete wavelet transform (DWT) in one dimension (1D),
2. quantization,
3. SPIHT encoding without data loss.

The ECG signal concentrates and the amplitude of the signal decreases with increasing frequency in the low-frequency zone. This disparity narrows from the top of the pyramid to its base. In addition, sub-bands have been shown to have a same temporal signature. Every node in the hierarchical pyramid has either no descendants or no descendants, as described by the tree of temporal orientation. All of these characteristics are evident in the signal's discrete wavelet transformation (DWT) [4].

Both recursive and non-recursive implementations of the 1-D DWT are at your disposal. Word Length-Growth (WLG) allows for a full recreation of the former, which otherwise needs floating-point computations.

Finally, a reversible transformation with minimum period may be obtained by inverting the theorem for linear transformations by a factor of two. Most recursive designs use interleaving on several levels. Non-recursive filtering and folding methods are used by the latter [11].

In contrast, linear distortion behavior may be achieved using a novel quantization technique that uses a uniform scale of quantization.

The SPIHT system uses a progressive mode for efficient bit rate management and is based on an exponential distortion versus compression ratio technique using a consistent 2n measuring scale. For nonlinear processes, distortion management is challenging.

3. Results And Discussions

The quantized wavelet coefficients are calculated independently using a lossless SPIHT technique. The SPIHT algorithm is the basis for the sorter and refiner components of most SPIHT coding systems. There are three possible passes: an insignificant set pass (ISP), an insignificant pixel pass (IPP), and a significant set pass (SSP). In the trial approach, three lists are employed to keep candidates in order. The time needed to process applications and the total number of applicants will both grow exponentially as the granularity of the breakdown is deepened. This consequence renders the commonly used SPIHT algorithm inappropriate for use in portable devices.

Electrocardiograms based on Wavelets The rebuilt system will consist of the following three processes:

Firstly, SPIHT Encoding

Quantum Inversion

3. DWT in reverse

Sub-clay encoding bit streams are concatenated into the coding sequence to form the whole input signal coding bit stream, which is then decoded backwards using the reverse lossless SPIHT decoding method for all data sign levels and magnitudes (as illustrated in Fig.1). The decoding of a bit stream occurs in stages. In order to reduce hardware and computational expenses and speed up the decoding process, this article makes use of the SPIHT decoding method, which produces loss-free decoding information.

When compared to the quantization cycle, inversion occurs in inverse quantization. Before feeding the Inverse DCT with the compressed ECG signal from the SPIHT decoder, it is necessary to transform the quantized values back to the original range in order to rebuild the ECG.

With the use of inverse DWT, the original ECG signal may be reconstructed from the estimated wavelet coefficients. By using the IDWT transform, a better electrocardiogram (ECG) signal may be achieved. Selecting a suitable wavelet transform. Furthermore, the

original ECG signal was restored.

The results show that the suggested technique is a viable method for compressing ECG signals. The experimental findings show that a high-quality classification result may be achieved despite the fact that some information is lost, i.e., the quality of the reconstructed signal is low. Because of this discovery, the intricacy of the issue of classifying arrhythmias in electrocardiograms is simplified.

Constraints: The Fourier transform can only be computed at discrete locations. One drawback of FT is that it cannot pinpoint the exact moment in time when the frequency component first appears.

If the signal-to-noise ratio (SNR) is 4dB (% of the root-mean-square difference), then most of the reconstructed signal is not discernible, as seen in Fig. 2(b). Even if the snr=6 dB is sufficient to reconstruct the majority of the ECG signal frames, there will still be some frames, as the second frame in Figure2 (c), that are too damaged for any clinically or diagnostically acceptable reconstruction to be obtained.

Normalized and original ECG waveforms at 4, 6, and 8 dB SNR receiver levels are shown in Fig. 2.

Figure 2 shows that most of the properties of the received ECG waveform, including the P wave, QRS complex, and T wave, may be retained for satisfactory quality when the signal-to-noise ratio (SNR) is 8 dB or above. This 8-dB case is equivalent to a 10-dB signal-to-noise ratio. Compressed SPIHT encoded/decoded/ECG data in question may be sent and received in the mobile tele cardiology test with a

BER (Bit Error Rate) of 10-5. The signal quality determines the required degree of compression for the data provided to medical specialists. Our Trial Base nevertheless gives a respectable reconstruction at a high CR(Compression) ratio of up to 20:1 because to the remarkable encoding efficiency of SPIHT

Table 1 SNR Level in PRD and BER

SNR(dB)	4	6	8	10
PRD(%)	487.32	10.2	1.04	1.04
BER	0.065	0.00088	0.00001	0.00001

SNR Level in PRD and BER as shown in Table 1. SNR = 4dB PRD is 487.32 and BER is 0.065%, SNR =6dBPRD is 10.2% and BER is 0.00088%, SNR = 8 dB PRD is 1.04 and BER is 0.00001%, SNR =10 dB PRD is 1.04% and BER is 0.00001%, The percent of root-mean-square difference is shown in Figure **Figure 3** shown in Figure 4.

Figure 4.

Table 2 Transmission and Receiving Time in SPIHT, Reduction Time, PRD

CR	4	8	16	20
ECG Compression With SPIHT Encoding	145 sec	73 sec	36 sec	29 sec
ECG Reconstruction With SPIHT Decoding	146 sec	74 sec	36 sec	29 sec
Reduction Time(%)	75	87.5	93.75	96
PRD(%)	0.58	1.01	1.93	2.41

Transmission and Receiving Time in SPIHT, Reduction Time, PRD as shown in Table 2. The CR (compression Ratio) = 4, ECG Compression with SPIHT Encoding Transmission time is 145sec. CR=8,ECG Compression

The transmission time for an electrocardiogram (ECG) compressed using SPIHT encoding is 36 seconds, with a CR of 16. The transmission time for an ECG compressed to CR=20 using SPIHT encoding is 29 seconds. Figure 5 depicts the Transmission Time in SPIHT.

When the compression ratio is 4, the time required to reconstruct an electrocardiogram using SPIHT decoding is 146 seconds. When the ratio is 8, the time required is 74 seconds. When the ratio is 16, the time required is 36 seconds. When the ratio is 20, the time required is 146 seconds. Figure 6: Received Time in SPIHT.

4 Conclusion

CR =4 Time has been cut in half. Time Reduction = 87.5% at CR= 8. CR =16 Time is reduced by 93.75 percent. The time reduction for a CR=20 is 96%. Time Cut in SPHIT, as Depicted in Figure 7. The CR=4, RPD=0.58, CR=8, PRD=1.01, CR=16, PRD=1.93, and CR=20, PRD=2.41 distributions are seen. Figure 8: Compression ratio and PRD.

Considering the ECG was sent throughout a 30-minute period. Without any kind of compression, it takes 584 s / (122200 b). In addition to the 1800s, you'll need 360 samples (at least 11 b each sample). In Table II, we see how long it takes to send a compressed signal at various compression rates. SPIHT's excellent coding efficiency makes the connection significantly more efficient, cutting down the time it takes to send the ECG signal on the testbed by 96%.

An electrocardiogram-based 1-dimensional wavelet data compression system with SPIHT VLSI architecture, high efficiency, and low power consumption is proposed. This technique attempts to lessen the burden on hardware by comparison to SPIHT and related methods. Used with 1-D wavelet data for ECG analysis. The quality of BER, PRD, and visual clinical review is evaluated. The simulation findings demonstrate that when SPIHT compressed ECG is sent properly under BER, a CR of 8:1 decreases the total mobile transmission time by 87.5 percent, and an increase in CR of 20 may further reduce the needed amount of time to transfer to the ECG by up to 96 percent. Clinically meaningful consistency in ECG interpretation may be achieved by reserving most ECG waveform components including the P wave, QRS complex, and T wave for abnormal heart rhythms..

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