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A Low Complexity and High Accuracy ECG Detection and Recording Based on Wavelet Transform

R. Gayathri, D. Ganeshkumar and V. Parimala

P.A. College of Engineering and Technology, Coimbatore, India

Abstract: Many hardware systems have been proposed for long-term ECG monitoring, which can be categorized as recording and analyzing systems. The recording system mainly implements ECG signal acquisition, storage and transmission. Long-term monitoring of electrocardiogram (ECG) is widely used for those who have cardiac diseases. By supporting data compression also, utilizing a double ping-pong-memory structural engineering, this configuration leads to a large reduction in the whole system energy. To decrease the equipment cost, the procedures of coefficients truncation and resource sharing are adopted. Importantly, parameters improvement and occasional expansion are utilized to improve quality of the reconstructed signal under high compress ratio (CR). Dictionary based code compression along with run length encoding provide good compression ratio along with fast decompression mechanism. The efficiency of these techniques is limited by the number of bit changes used during compression. Compared to previous implementation on the same chip, this implementation achieves better compression efficiency with accurate peak detection. The VLSI architecture implementation could be done in MODELSIM for verification.

Key words: Dppm · Dictionary based code · VLSI Architecture

INRODUCTION

Wireless body sensor system advancements guarantee to offer large-scale and cost-effective solutions to this issue. These arrangements comprise.

In equipping patients with wearable, miniaturized and wireless sensors able to measure and remotely report heart signs to tele health providers [1, 2]. They are poised to enable the required personalized, constant and long haul mobile observing of unending patients, its seamless integration with the patient's medical record and its coordination with nursing/therapeutic backing. The analysis of the ECG is widely used for diagnosing many heart illnesses, which are the primary driver of mortality in developed countries.

Since most of the clinically useful data in the ECG is found in the interims and amplitudes defined by its significant points (characteristic wave peaks furthermore, limits), the improvement of precise and powerful methods for automatic ECG delineation is a subject of major importance, especially for the analysis of long recordings [3]. Indeed, QRS location is necessary to determine the heart rate and as reference for beat arrangement; ECG wave delineation provides fundamental features (amplitudes furthermore, interims) to be utilized as a part of ensuing programmed examination [4, 5, 6].

While the resting ECG monitoring is standard practice in healing facilities, its wandering partner is as yet confronting numerous technical challenges. For instance, the three-lead ECG is still these days recorded on a somewhat cumbersome and prominent commercial data logging device during one to five days of normal daily activities of a patient. Based on these premises, it is today acknowledged that the achievement of truly WBSN-enabled wandering checking frameworks requires more achievements not only in terms of ultralow- power read-out electronics furthermore, radios, additionally and progressively in this way, regarding ultra-low-control dedicated digital processors furthermore, related inserted highlight extraction and information pressure algorithms.

In the conventional lexicon based pressure approach, the dictionary entry selection process is simplified since it is clear that the recurrence based choice will give the best compression ratio. However, when compressing

Corresponding Author: R. Gayathri, P.A. College of Engineering and Technology, Coimbatore, India.

using bitmasks, the issue is mind boggling and the recurrence based selection will not always yield the best compression ratio. At the point when one and only lexicon section is permitted, the unadulterated recurrence based selection will pick "00000000", yielding the pressure proportion of 97.5%. However, if “01000010” was chosen can achieve the compression ratio of 87.5%. Clearly, there is a need for proficient veil determination and lexicon choice strategies to improve the efficiency of bit mask-based code compression. It is worthy as well as every now and again helpful to permit length-separation sets to indicate a length that really surpasses the separation. As this type of pair repeats a single duplicate of information numerous times, it can be utilized to fuse a flexible and easy form of run-length encoding.

This proposed improves the quality of reconstructed signal by parameters optimization and periodic extension. In addition, the fixed-point algorithms of recording and detection modes are implemented by the CPU on the same chip, which indicates that ASIC gains higher energy efficiency. Thus, our work reduces system energy with a little increase in chip area and gains high quality of reconstructed signal, which is very suitable for energy-limited and low-cost long-term ECG monitoring.

Existing Energy-Efficient Design for ECG Recording and Detection: ECG Detection Algorithms Generally, ECG signals are corrupted by various types of noises generated from the human body. For example, the Electromyographic (EMG) signal from muscle contraction and relaxation may cause a degradation of signal-to-noise ratio (SNR). Body movement also causes baseline drifts of variable DC-offsets[3]. Many detection algorithms have been proposed to eliminate the noise effects and precisely detect the peak points of the ECG signal. To achieve high detection performance, an artificial neural network algorithm was used. However, the building of the ECG statistic model can incur a large computational burden. The combined algorithm, which exploits both the neural network based adaptive filtering and wavelet transform, is also too complex for VLSI implementation. Considering the trade-off between the hardware complexity and the detection accuracy, the wavelet based detection algorithm is generally considered as one of the most effective algorithms. The previously proposed wavelet ECG detector consists of wavelet filter banks (WFBs) as a wavelet decomposer, a generalized likelihood ratio test (GLRT), with the threshold function as a QRS [6], [7] complex detector and a noise detector with zero-crossing points are presented. First, the WFBs decompose the input ECG signals into sub-bands with two monophasic and biphasic outputs. The GLRT with threshold function estimates the heart-beating rate with the decomposed WFB outputs. The noise detector reduces the power consumption by determining the operation mode according to the SNR of the ECG input signal. Wavelet Decomposer: Due to its property of low computational complexity, the dyadic wavelet transform is generally considered suitable for implementing the ECG detector. To implement the dyadic wavelet transformer, both the decimator (down sampler) based and undecimator based architectures with the filter pairs of low-pass filter (LPF) and high-pass filter (HPF) have been proposed. The undecimator based architecture has the advantage of translation-invariance but requires a constant clock and many registers. To reduce the number of registers, the lifting based structure is frequently used, which reduces the delay elements as well as the arithmetic operations by constructing the lifting wavelets of the second generation wavelets. However, the lifting scheme cannot be applied to all types of wavelet function families.

Existing Ecg Monitoring System: The proposed system used to design an energy-efficient ASIC system for both ECG recording and R-peak detection. First, we propose a compression method to decrease transmission energy, as well as dual-ping-pong-memory (DPPM) architecture to reduce digital energy. Second, coefficients truncation and resources reusing are adopted to reduce the cost increase caused by low energy design. Moreover, for this resource-constrained system, our work improves the quality of reconstructed signal by parameters optimization and periodic extension. In addition, the fixed-point algorithms of recording and detection modes are implemented by the CPU on the same chip, which indicates that Thus, our work reduces system energy with a little increase in chip area and gains high quality of reconstructed signal, which is very suitable for energy-limited and low-cost long-term ECG monitoring. Generally, transmission energy (the major of system energy) and digital energy can be reduced by data compression and lowering frequency, respectively. However, data compression needs larger chip area and lower frequency requires larger data buffer, which both result in increase in cost. Meanwhile, for such a cost-limited system, parameters should be optimized carefully to improve the signal quality. ECG recording and R-peak detection are combined and (the former detects R-peak

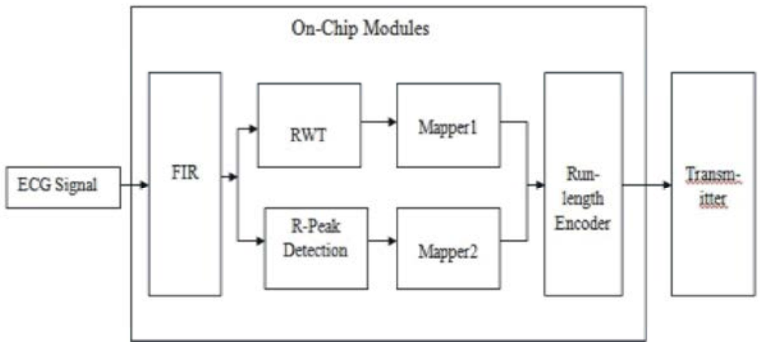

Fig. 1: Block Diagram of ECG monitoring system

with hardware while the latter with software), but raw data transmission consumes most of the system energy. Transmission energy is reduced by compression; however, they provide poor signal reconstruction under higher CR. In, compression is accomplished by an analog-to digital converter with adaptive sampling, but R-peak detection with software results in a higher cost.

As we know, the first report on ASIC design of ECG compression and R-peak detection was in but without silicon-proven results. Because wireless transmission consumes more than 90% of the system energy in ECG monitoring, this work optimizes energy by reducing the amount of transmitted data in both recording and detection modes. As shown in Fig. 1. In recording mode, the finite-impulse response (FIR) is configured as the low-pass filter of the bior4.4 wavelet and ECG signals are compressed based on wavelet transform (WT) and run-length encoding (RLE), whereas in detection mode, we configure the FIR as the down sampling filter designed in our previous work . This work presents an ASIC design of that algorithm and compresses the R-peak location by RLE. Finally, both compressed ECG signals and R-peak location are sent by a transmitter.

ECG Monitoring System

Features of WT Coefficients: In recording mode, the ECG signal x(n) is compressed based on segment with length N. We decompose the signal segment with filter banks using the bior4.4 wavelet. The bior4.4 wavelet provides perfect reconstruction using linear-phase filter banks, which in turn avoids reconstruction errors at the beginning and ending of data segments . Based on theMIT–BIH database (MITDB) [8], it depicts the average amplitude of decomposition coefficients up to level 10, which shows sharp divergences between different frequency bands. value than the coefficients of other levels. Feature is as follows, Step 1) The binary matrix is connected to build a binary sequence. Due to a large number of zero elements at the upper right of the matrix, there exist many consecutive zero elements in the binary sequence. Step 2) As shown in Fig. 1, elements of the binary sequence in Step 1 are mapped by Mapper1 based on the following rule: y = ◎◎ ◎ 2_b01, Zero element 2_b10, Nonzero element & x > 0 2_b11, Nonzero element & x < 0 (1)where x corresponds to the decomposition coefficient that possesses the element being mapped. Step 3) The consecutive zero elements are compressed by RLE, whereas the nonzero elements remain unchanged.

ECG Compression: We apply the fixed-point processing on decomposition coefficients. It is observed that the fixed-point coefficients distribute like a binary matrix, where a large area of zero elements exists at the upper right. Our work presents the ECG compression method based on this.

Existing Method to Compress R-Peak Location: In previous work presented a detection algorithm with only one FIR filter for low-power design . Because the isolation of R-peak produces many consecutive zero elements within the detection results, this work compresses the results by RLE to further lessen the transmission vitality. To start with, to keep consistent with the RLE used in Section II-A.2, the R-peak location is mapped by Mapper2, which is defined as y = _ 2_b10, R-peak 2_b01, others. (2) Second, same as given in Step 3, we compress the outputs of Mapper2 by RLE.

In design implements ECG recording and R-peak detection, which are regarded as the most important functions of longterm ECG monitoring. The ECG signal is first stored in first-in, first-out (FIFO) with a slower clock, a sampling rate of MITDB 360 Hz, whereas the FIR reads it with a faster clock. In recording mode, the FIR is configured as the low-pass filter of the bior4.4 wavelet to implement the first-level WT; thus, only the approximation

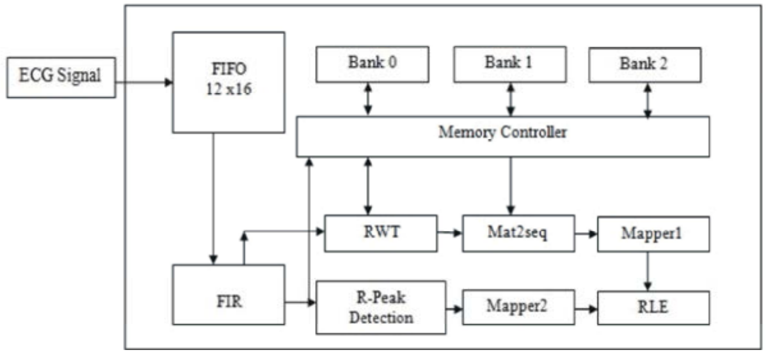

Fig. 2: Architecture of the Existing system low- and high-pass filters

part is stored in the allocated memory. The FIR produces one of the segment output with length N, signal firDone is asserted to introduce the calculation of RWT. When RWT is finished, we assert signal wtDone to start Mat2Seq, Mapper1 and RLE modules in sequence. Signal compDone is asserted to complete recording. In detection mode, the FIR is configured as the downsampling filter mentioned in Section II-B and its outputs are fed into the detection module without saving.The R-peak location is then mapped by Mapper2. In both modes, the outputs of Mapper1 and Mapper2 are compressed by RLE. To reduce energy consumption, our design gates clocks of idle modules with signal gating.

As shown in above Fig. 2, DPPM architecture is proposed to reduce the digital energy by lowering the working frequency. Although data compression and DPPM increase the chip area, our work presents coefficients truncation to reduce the memory size; moreover, the chip area is decreased by resources reusing.

DPPM Architecture: The DPPM architecture is designed with signals PP0 and PP1, as shown in Fig. 2. In the traditional architecture, the same memory bank is shared by ECG signal storage, WT and Mat2Seq; thus, WT and Mat2Seq must be done before the arrival of the next ECG data, which results in high working frequency. Ping-pong architecture with PP0 decreases the working frequency by using Bank0 and Bank1 interchangeably between ECG signal storage and WT. Meanwhile, ping-pong architecture between WT and Mat2Seq is implemented by PP1. In design always stores the detail part of WT in bank2, which is read by Mat2Seq as soon as the WT is completed..

Coefficients Truncation: In work halves the memory size by saving only the approximation part of the first-level WT, where the LPF of coefficients truncation is implemented by FIR. With a sampling rate of 360 Hz, the first-level WT provides approximation and detail parts with frequency bands of 0–90 and 90–180 Hz, respectively. Hence, our work reduces the memory size by half while achieving good reconstruction.

Resources Reusing: In system shares three modules to reduce the chip area, namely, FIFO, FIR and RLE. In detection mode FIR is configured as the down sampling filter designed in while as the low pass filter of the first designed in while as the mode.

Dictionary Selection Method: Dictionary based code compression methods are very popular because they afford both good compression ratio and fast decompression mechanism. The efficiency of these methods is limited by the number of bit changes used during compression. The cost of storing the information for more repeating instruction sequences. The input configuration bit-stream is read sequentially in the reverse order [9]. Then, the dictionary and the index are derived based on the principles of the well-known LZW compression algorithm. The original configuration bit-stream can be reconstructed by parsing the dictionary with respect to the index in reverse order. The achieved compression ratio is the ratio of the total memory requirements to the size of the bit-stream.

The existing compression techniques are classified into two categories. The techniques in the first category have good compression ratio due to complex and variable-length coding (VLC) . However, they also need expensive decompression hardware, which may not be acceptable for practical implementation. The other category of compression approaches accelerate decompression using simple or fixed-length coding (FLC) and therefore have very efficient decompression hardware. Among various

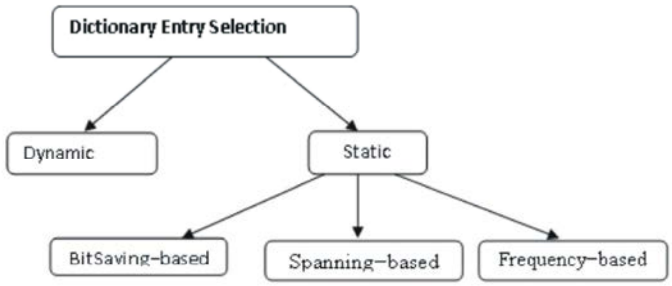

Fig. 3: Block diagram of proposed Method

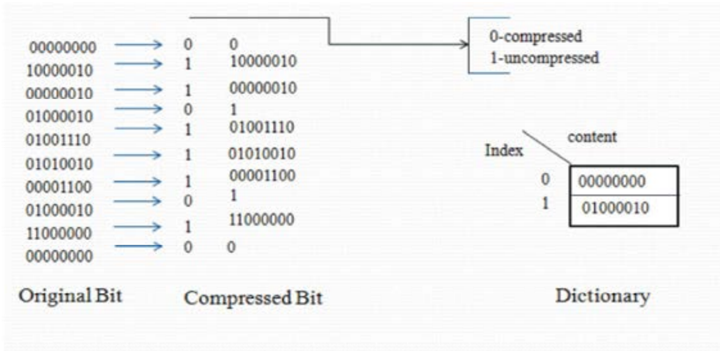

Fig. 4: Dictionary-based code

compression techniques that has been proposed in recent years, application of dictionary-based method seems to be attractive for compression, because of its good compression ratio and relatively simple decompression scheme. Moreover, the use of variable-length coding is challenging for the design of decompression hardware because it requires expensive buffering circuitry.

Hence, it is a major challenge to develop an efficient compression technique that can significantly reduce the bitstream size without sacrificing the decompression performance. Our approach combines the advantages of previous run length compression techniques with good compression ratio and those with fast decompression.

This paper makes three important contributions. First, it performs compression to enable fast decompression of variable-length coding. Next, it selects bitmask-based compression parameters suitable for bitstream compression. Finally, it efficiently combines run length encoding and dictionary-based compression to obtain better compression and faster decompression.

Dictionary-Based Code Compression: Fig. 4. shows an example of the standard dictionary-based code compression. The sample program is made up of ten 8-bit binaries (total 80 bits). The dictionary has two 8-bit binaries [10]. The dictionary corresponds to configuration data and the file compares to the way the dictionary is read in order to reconstruct a configuration bit-stream. Every rehashing example is supplanted with a word reference record.. The final compressed program is reduced to 60 bits and the dictionary requires 16 bits. For this situation, the compression ratio is 97.5%. The repeating occurrences are replaced by a codeword that indicates the file of the dictionary that contains the pattern. However, consider only one edge between two nodes corresponding to the profitable mask (maximum savings). Next, the calculation chooses the hub with the greatest general savings as an entry for the dictionary. Another major challenge in bitmask-based compression is the means by which to perform dictionary selection where existing and in addition bitmask-coordinated reiterations need to be considered.

RESULT AND DISCUSSION

The Proposed system based dictionary selection based VLSI architecture has been verified and designed by using MODELSIM. ECG wave generation. Clk is the input clock signal and count is the value for determining the magnitude of the P, Q, R and S wave. ECG_out is the output ECG signal obtained by setting the analog properties in the modelsim. Recording and detection is the memory used to store the binary data of its corresponding signal. RLE_OP is the final compressed output.

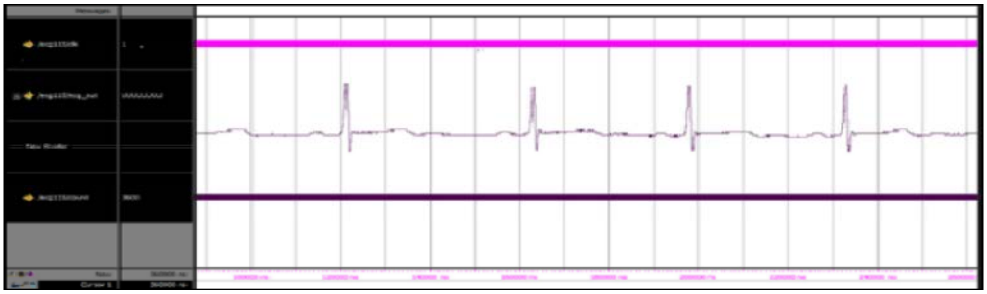

Fig. 5: Simulation result for the ECG signal

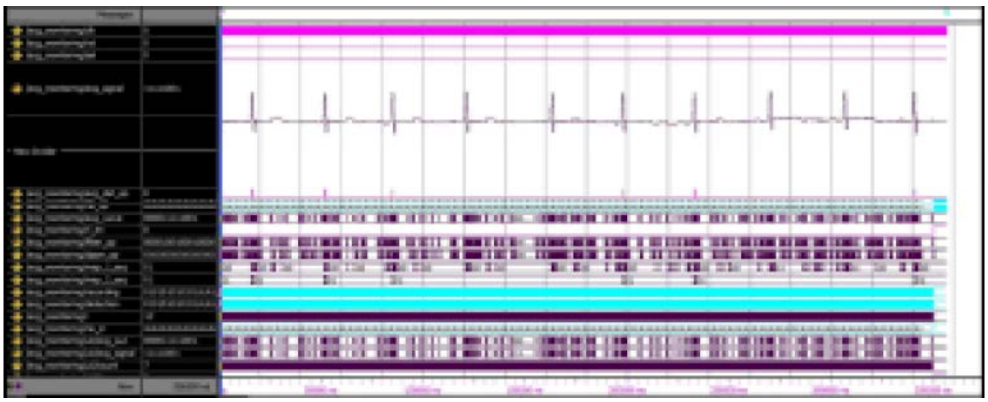

Fig. 6: Simulation result for the RLE and dictionary based selection

CONCLUSION

In this paper we have proposed reduced by compression and DPPM architecture. The system energy consumption is reduced by compression and DPPM archi We propose coefficients truncation and resources sharing to lower the system cost. Meanwhile, parameters optimization and periodic extension of decomposition coefficients are presented to provide high quality of reconstructed signal while achieving high compression rate. By supporting information pressure and utilizing a double ping-pong-memory structural engineering, this design leads to a large reduction in the whole system vitality. Compared to previous implementation, this implementation achieves a 41% compression ratio along with high accuracy in peak detection. selection based compression technique to increase the compression ratio.

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