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Low-Power Lossless ECG Encoder SOC Engine Design for Wireless Body Sensor

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Abstract

To design an efficient VLSI architecture of a lossless ECG encoding circuit for wireless healthcare monitoring application.This system eventually helps in hospitals for easily to monitoring the patient ECG signal at 24 hour in house or healthcare.This technology can also be well utilized in all regions. For ECG signal compression andin order to save wireless transmission poweranovel lossless encoding algorithm is proposed. This algorithm containsa novel adaptive predictor which is based on fuzzy decision control, and a novel hybrid entropy encoder including both a two-stage Huffman and a Golomb-Rice coding. Compared to previous low-complexity and highperformance lossless ECG encoder studies, this design is expected to have a higher compression rate, lower power consumption and lower hardware cost than other VLSI designs.

Keywords: Lossless ECG encoding algorithm, Adaptive fuzzy predictor, Two-stage Huffman encoder, golomb–rice encoder,FPGA..

Introduction

An electrocardiogram or ECG, is a simple, painless test that records the heart's electrical activity. To understand this test, it helps to understand how the heart works. With each heartbeat, an electrical signal spreads from the top of the heart to the bottom.

As it travels, the signal causes the heart to contract and pump blood. The process repeats with each new heartbeat. The heart's electrical signals set the rhythm of the heartbeat. The electrocardiogram (ECG) is an important biomedical signal and widely used to establish clinical diagnosis of heart diseases. The traditional ECG recorder transmits the ECG data by cables, which is incompetent for real-time monitoring in mobile scenarios or 24-hour healthcare. In recent years, wireless homecare services have been widely discussed and are of interest in academic and commercial researches. Similar to other wireless mobile systems, power saving is necessary for the long-term usage of wireless ECG recorders. For this reason, a data compression technique can be used to not only reduce transmission energy but also transmit more data by the wi-fi.

In our previous work Burrows-Wheelertransform and MTF transforms used for lossless ECG compression algorithm.This method reaches high compression for losslessECG compression.But, it is not easy to implement into VLSI circuits and low power consumption.Golomb-Rice coding used for lossless ECG compression algorithm.It provided efficient VLSI architectures and reduces hardware cost and power consumption.But more to develop a low-cost and long-term usage wireless monitoring system.

Recently an adaptive predictor andtwo-stage entropy encoder algorithms are used for high-compression-rate of lossless ECG encoder.It provides the better power and lossless consumption.

The proposed algorithm consists of a noveladaptive predictor based on fuzzy decision control, and a novel hybrid entropy encoder including two-stage Huffman and a Golomb-Rice coding as well.For getting the better lossless and power consumption,better accuracy in real time applications, lossless ECG encoding algorithm has been used: The proposed lossless ECG encoding algorithm consists of an adaptive fuzzy prediction and a hybrid entropy coding technique. The hybrid entropy coding methodology is composed of two-stage Huffman and GR coding techniques. The details of each part are described below

Adaptive fuzzy prediction: In fuzzy prediction first, the current value x(n) can be obtained by the past three values of x(n − 1), x(n − 2) and x(n − 3) by the fuzzy decision. The input value Diff1 is the difference between x(n − 2) and x(n − 3) and Diff2 is the difference between x(n − 1) and x(n − 2). Secondly, the absolute values of Diff1 and Diff2 can be determined as high or low by a threshold. Thirdly, the Diff1 and Diff2 can be classified as the same or

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different directions according to the slope directions of Diff1 and Diff2.Four prediction functions can be adaptively selected by the fuzzy decision according to the difference, absolute value and slope direction parameters. The equations of the four prediction functions, F1, F2, F3 and F4.

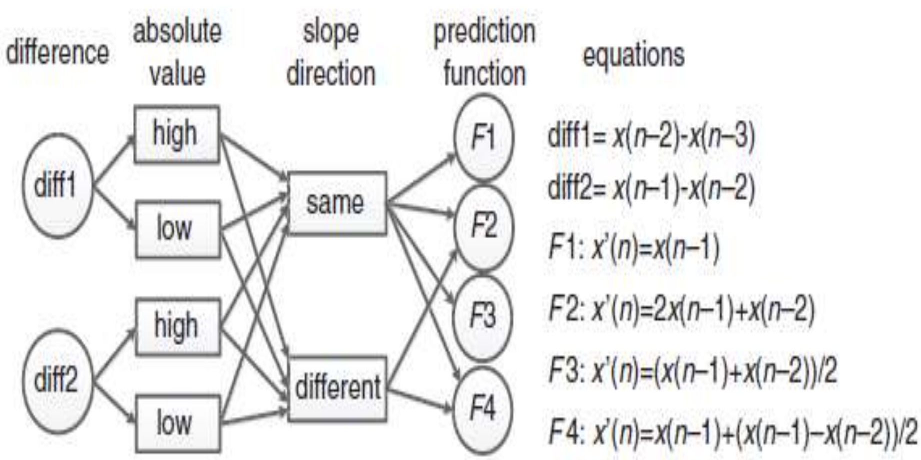

Fig. 1 Adaptive fuzzy prediction

Two-stage Huffman coding:Huffman coding tree, the two-stage Huffman coding technique can be used to reduce the complexity of the Huffman coding efficiently by separating a big Huffman coding tree into two smaller ones. As shown in Fig. 2, the values of prediction difference (PD) which range from − 3 to 4 are encoded by the first Huffman table. If the value of PD is over the range of the first Huffman table, it would be sent to the second Huffman table for encoding.

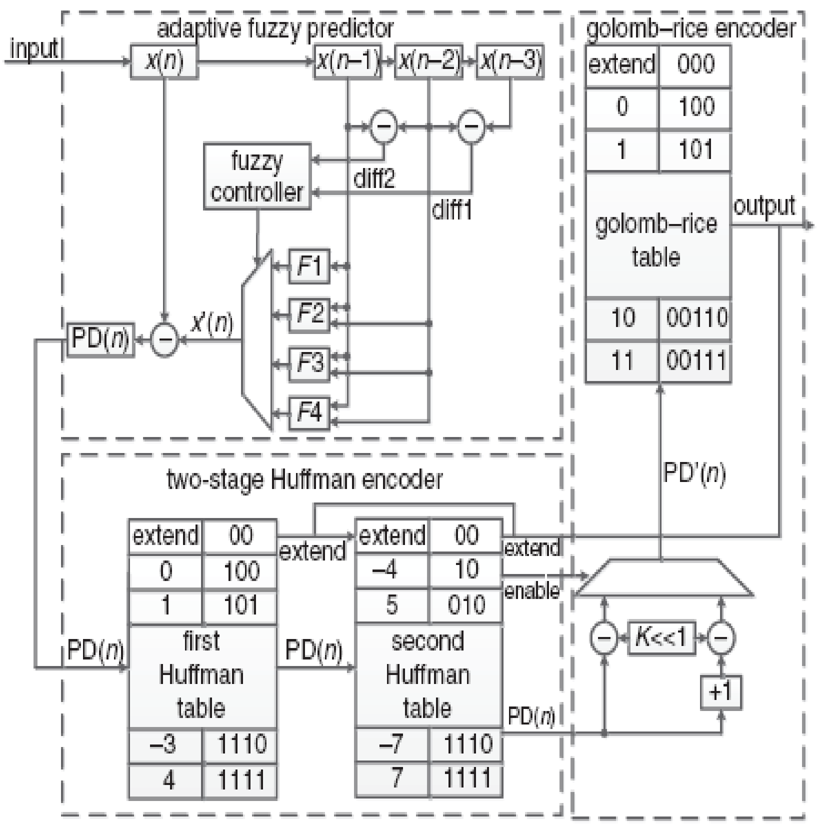

Fig. 2 Architecture of proposed lossless ECG encoder

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GR coding: GR is one kind of variable-length code, a lossless data compression method using a family ofdata compression. which is widely selected as an entropy coding method since it has the benefits of low complexity and high coding performance. The concept of GR is that the smallest value can be encoded by the shortest codes, and the largest value represented by the longest codes. The binary codes can be generated by the GR method according to the relations between the quotient and the remainder. Thus, the PD can be transformed into a smaller value of PD′(n) by

$$PD'(n) = \begin{cases} 2 \times PD(n) - 2 \times K, & PD(n) \geq 0 \\ 2 \times PD(n) - 1 - 2 \times K, & PD(n) < 0 \end{cases} \quad (1)$$

where K is the value of the first position in the GR table as shown in Fig. 2. Hence, the value of PD′(n) can be encoded by a binary code which is mapped in the GR table.

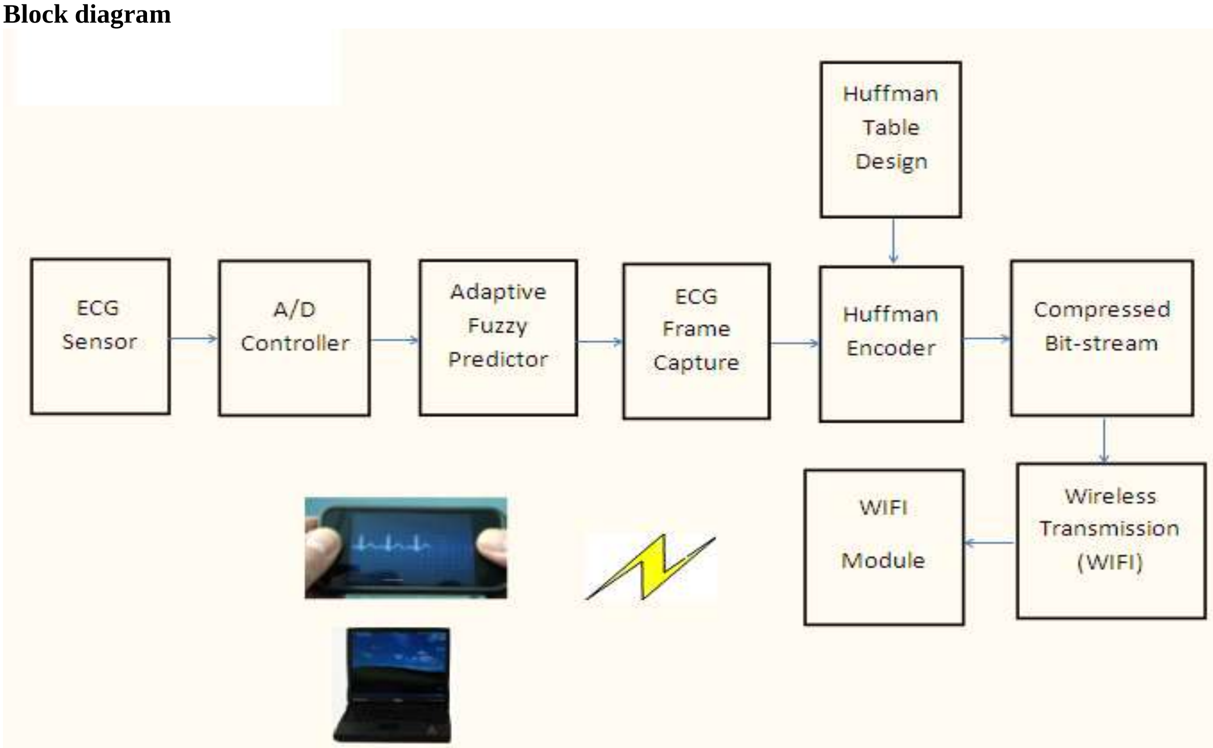
Proposed system

VLSI architecture: Fig. 2 shows the architecture of the proposed lossless ECG encoder. The proposed lossless ECG encoder consists of an adaptive fuzzy predictor and a hybrid entropy encoder. The detailsof each part are described below.

Adaptive fuzzy predictor: It consists of five registers, three subtractors, one multiplexer, four prediction function generators and one fuzzy decision controller as shown in architecture diagram. The register PD(n) is not only used to store the value of PD, but also designed as a pipeline register to improve the performance of this design. The values of Diff1 and Diff2 can be obtained by two subtractors. After receiving the values of Diff1 and Diff2,the fuzzy controller can produce a control signal to select a result as x′(n) from one of the four prediction function generators F1, F2, F3 and F4.Finally, the PD can be produced for entropy coding by obtaining the difference between x(n) and x′(n).

Hybrid entropy encoder:It consists of two-stage Huffman and GR encoders. Both of these variable-length coding methods were realized by the architecture of look-up tables.The Huffman coding depends on the depth of the Huffman coding tree, it is more efficient to implement the Huffman encoder by the VLSI architecture of two Huffman tables than just one.If the value of PD(n) is out of range by these two Huffman tables, it should be sent to the GR encoder for encoding. Secondly, the PD′(n) is selected from these two values according to the sign of PD(n). Finally, the PD′(n) is encoded by the GR table, and then sent to the output for transmission.

Block diagram



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Block diagram description

The ECG signal is transferred from ECG sensor to A/D controller so that the FPGA can accept the digital signal.The Fuzzy predictor predicts forecoming signal.In the ECG Frame Capture the signal is sampled bit by bit.Each sample signal is compressed by the Huffman encoder with the help of Huffman table. Eventually, the signal will be transferred through wi-fi to the system. Finally the signal will be decompressed and displayed in the pc or mobile.

Results and discussion

Table 9. Comparison

	PI	PID	FUZZY
SPEED(rpm)	1500	1500	1500
Settling time of speed	0.8	1.8	0.4
Speed fluctuations	±20rpm	±10rpm	-
Torque ripples	±6	±0.5	±0.05

Conclusion

In this project, a cost-efficient and high-compression-rate lossless ECG compressor is proposed. A novel lossless compression algorithm based on a fuzzy decision control and hybrid entropy coding techniques is developed. The total project can be design in FPGA architecture for the main benefits of low cost, low power consumption and the low memory/area allocation high performance, and a high compression rate.By the application of wireless technology using for real time ECG monitoring systems is performed and the operating range of the whole system could be improved by application of further wireless methods such as GPRS/GSM models. Through this project i am looking for much accuracy/result for real time applications.

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