Empirical Mode Decomposition Based on ECG Analysis Design

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Abstract-The electrocardiogram (ECG) has been widely used for diagnosis purposes of heart diseases. Good quality ECG is utilized by the physicians for interpretation and identification of physiological and pathological phenomena. However, in real situations, ECG recordings are often corrupted by artifacts. One prominent artifact is the high frequency noise caused by electromyogram induced noise, power line interferences, or mechanical forces acting on the electrodes. Noise severely limits the utility of the recorded ECG and thus need to be removed for better clinical evaluation. A new ECG denoising method based on the recently developed Empirical Mode Decomposition (EMD) is proposed to diagnosis the ECG abnormality on System on Chip Architecture.

The Empirical Mode Decomposition (EMD) is becoming increasingly popular for the multi-scale analysis of signals. However, the data-driven and adaptive nature of the EMD raises concerns regarding the uniqueness of the decomposition as well as the extent to which oscillatory modes can be mixed across different IMFs. The method is validated through experiments on the MIT-BIH database. Both quantitative and Qualitative results are given. The results show that the proposed method provides very good results for de-noising. The proposed architecture is designed and synthesized with the Matlab.

Keywords: Empirical mode decomposition, Electro cardio graph.

I.INTRODUCTION

Electrocardiogram (ECG) signal can be used to count the heart rate beat for various diagnostic purposes in medicine. There are many research are related to the ECG signal such as fatigue driver detection using ECG signal. However, most of the captured ECG signal will be distorted by the noise that cause by the measurement instrument. Sometimes, the noise will totally mask the ECG signal. The signal is hardly to be processed for further analysis. Therefore, it is essential that the ECG signal must be filtered to avoid the failure detection of the signal. The output of ECG signal is compared with the ECG signal before filtering by plotting the signal in time domain and frequency domain using MATLAB.

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ECG signal can be applied in the detection of a fatigue driver whether he is sleepy. However, the captured ECG signal is distorted by noise caused by measurement equipment. The presence of noise will lead to failure detection of the ECG signal in further analysis. Moreover, it is essential to minimize the hardware resources used in FPGA.

Having a lot of multiply units is not area efficient. Therefore, it is essential to filter the noise that exists in ECG signal and implement an optimized hardware in FPGA.Empirical Mode Decomposition is a recent development which provides a powerful tool for decomposing a signal into a finite number of IMFs (Intrinsic Mode Functions). Empirical Mode Decomposition (EMD) has been used in a number of literature for R-peak detection as well as enhancement. The hilbrt-huang transform (hht) is widely adopted in analyzing biomedical signal, including electrocardiograph electro encephalography (eeg), etc the empirical mode decomposition (EMD) are the key component of HHT. EEMD ensembles the results of multiple EMD with different noise aids to solve mode mixing. In home care application the portable device requires low latency and low energy consumption for HHT computation. The EMD is key component of HHT to decompose data into intrinsic mode function (IMF) and a residue therefore an efficient VLSI design of the EMD engine is describe for future application..

II.REVIEW OF EMD ALGORITHM

A. EMD

In order to obtain correct instantaneous frequency in Hilbert transform, the EMD decomposes data into IMFs. The IMF must satisfy two conditions: 1) the number of extrema and the number of zero crossings must either be equal or different at most by one; and 2) the means of upper and lower envelopes must be zero at any time. The steps of EMD are summarized as follows.

At initial setting, both c(t) and d(t) are set to input data x(t).

1) Identify the extrema.

2) Generate the upper envelope U(t) and lower envelope L(t) from maxima and minima by CSI.

3) Compute the means m(t) = [U(t) + L(t)]/2.
4) Sift mean: new c(t) = c(t) − m(t).
5) Repeat steps 1–4 until the tenth iteration. Then, c(t) is new IMF Ci. New d(t) = d(t) − c(t) and new c(t) = new d(t) are the remains of IMF Ci.
6) Repeat steps 1–5 until the residue remains. After EMD, the data can be represented as a summation of multiple IMFs Ci(t) and a trend (residue) Res(t)

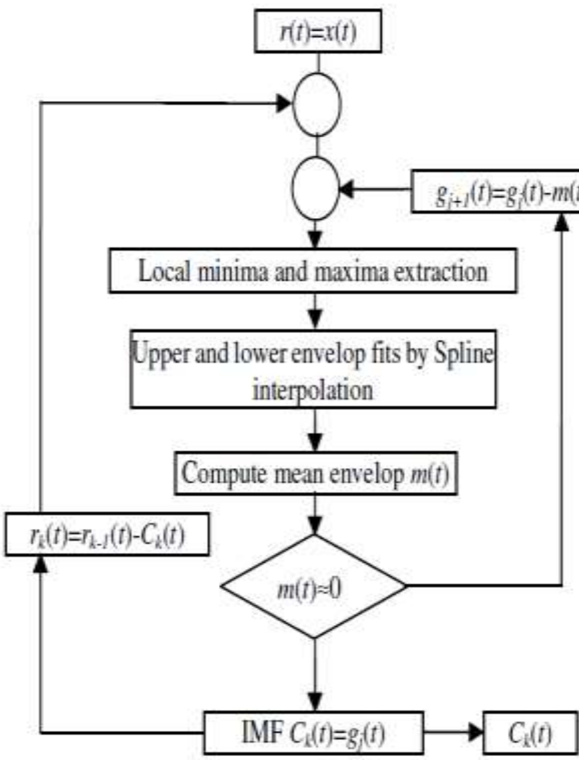

Fig.1. EMD Flow chart

Anew non-linear technique, called Empirical Mode Decomposition method, has recently been developed by N.E.Huanget al for adaptively representing non-stationary signals as sums of zero mean AM-FM components. EMD is an adaptive, high efficient decomposition with which any complicated signal can be decomposed into a finite number of Intrinsic Mode functions (IMFs). The IMFs represent the oscillatory modes embedded in the signal, hence the name Intrinsic Mode Function. The starting point of EMD is to consider oscillations in signals at a very local level. It is applicable to non-linear and non-stationary signal such as ECG signal. An Intrinsic Mode function is a function that satisfies two conditions:

(1) The number of extrema and the number of zero crossings must differ by at most 1.

(2) At any point the mean value of the envelope defined by maxima and the envelope defined by minima must be zero.

III.VLSI IMPLEMENTATION OF THE EMD ENGINE

A. Overall Block Diagram of the EMD Engine

Fig. 2 shows the architecture of proposed ping-pongmethod.Ei,jindicates the input of the sifting process for the ith component and jth iteration. In the ping-pong architecture, the buffer for t, C_ k, and D_ k is reordered to the starting component of the sifting process. Since the EMD sifts the low-frequency (LF) means from the high-frequency (HF) components in each iteration, the two data memory devices are used to record the HF and LF data separately. At the beginning of EMD, input data are loaded from the LF memory to find extrema. Then, the processing units (PUs).

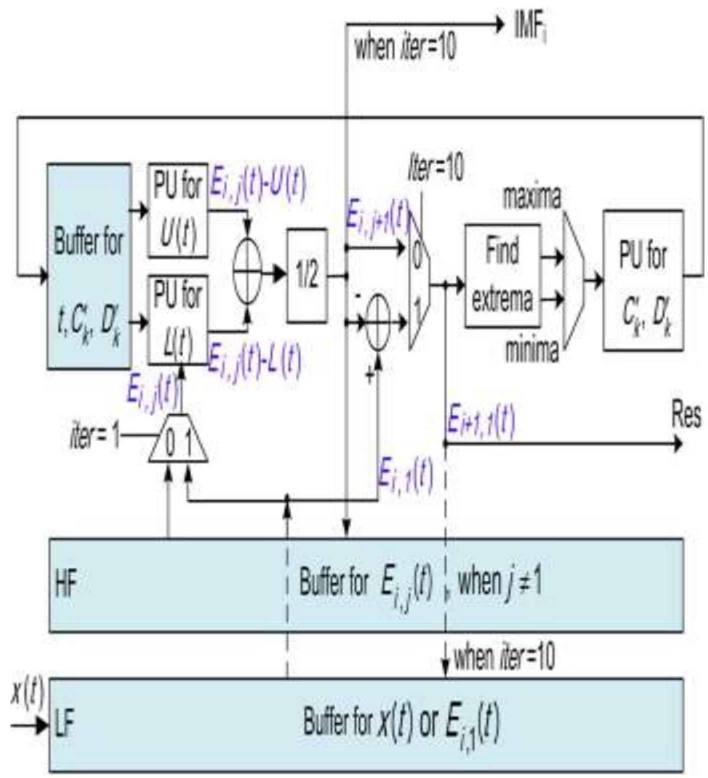

Fig. 2. Block diagram of the EMD engine.

B. Implementation Results

The proposed ping-pong architecture is implemented by a Taiwan Semiconductor Manufacturing Company 90-nm 1P9M CMOS process, and the layout view is shown in Fig. 3. In order to compare with, the same 16-bit fixed-point precision as is set, and the window size is set to 256 samples for matching the sampling rate (256 samples/s) of EEG signal. The chip area is 1.32 mm2, and the memory is only 2.3 KB. The maximum operating frequency can reach 50 MHz. The total latency is 0.27 ms for five IMFs (54 μs per IMF), which is only10% of (2.78 ms). For the first three IMFs, the latency is 0.16 ms and the energy is 2.2 μJ. The latency is much smaller than 4.7 s of because the data-reuse scheme must compute at least four times of CSI-backward coefficient than

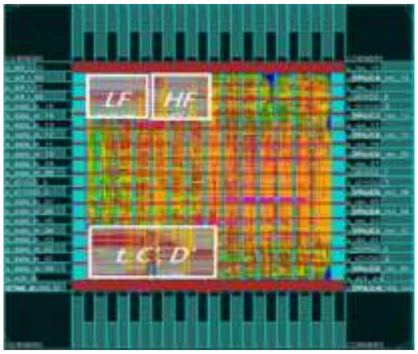

Fig. 3. Layout view of the proposed ping-pong architecture for EMD algorithm

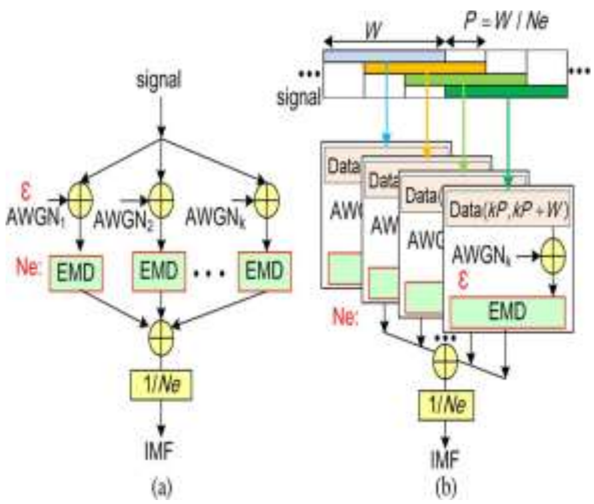

Fig. 4. (a) Conventional EEMD uses the same data to process EMD with noise aids. (b) Sliding EEMD uses sliding window as the input of each EMD block.

The boundary effects can be reduced in ensemble. The conventional method, as mentioned in Section III-A. The frequent computation in data-reuse scheme also increases the energy of accessing memory. Therefore, the proposed pingpong architecture reduces the energy consumption to 1%. The window size W, IMF number M, and sifting number R can be set depending on applications. The memory size is only 10% of because allocates buffers for all iterations. The buffer size of isroportional to M × R iterations, and the proposed ping-pong architecture reuses the same buffer for all iterations. Therefore, the buffer size in this brief is only proportional to W. No matter how the iteration number orIMF number changes, the buffer size is fixed. As a result, the core area in this brief is only 46%. In order to extend to other applications, only the memory area is proportional to the window size W. The combinational area is fixed when the precision is fixed to 16 bits. Therefore, the proposed ping-pong architecture is easily scaled to other applications.

IV.SOFTWARE REQUIREMENT AND DISCRIPTION

The operating system used is Windows 7 and the tool used is Matlab of version 7.10. MATLAB is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numerical computation. Matlab is a data analysis and visualization tool which has been designed with powerful support for matrices and matrix operations. As well as this, Matlab has excellent graphics capabilities, and its own powerful programming language. One of the reasons that Matlab has become such an important tool is through the use of sets of Matlab programs designed to support a particular task.

V.EXPERIMENTAL RESULTS

A. INPUT AND RECONSTRUCTED SIGNAL

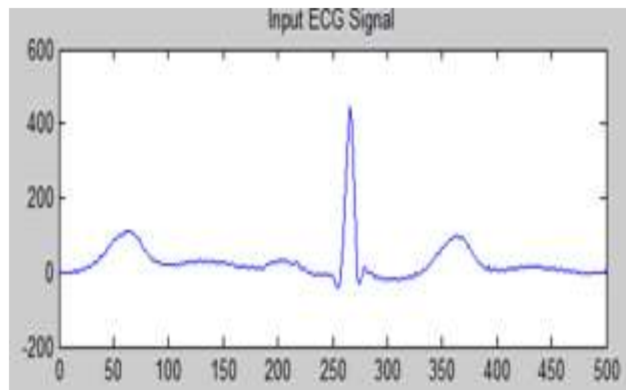

Fig .5 input Ecg signal

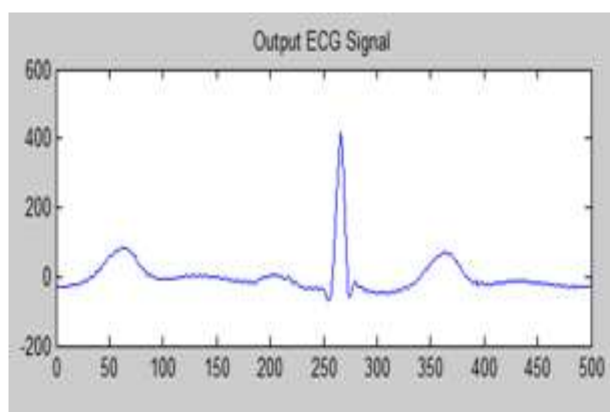

Fig .6 Reconstructed original signal

B. INTRINSIC MODE FUNCTION

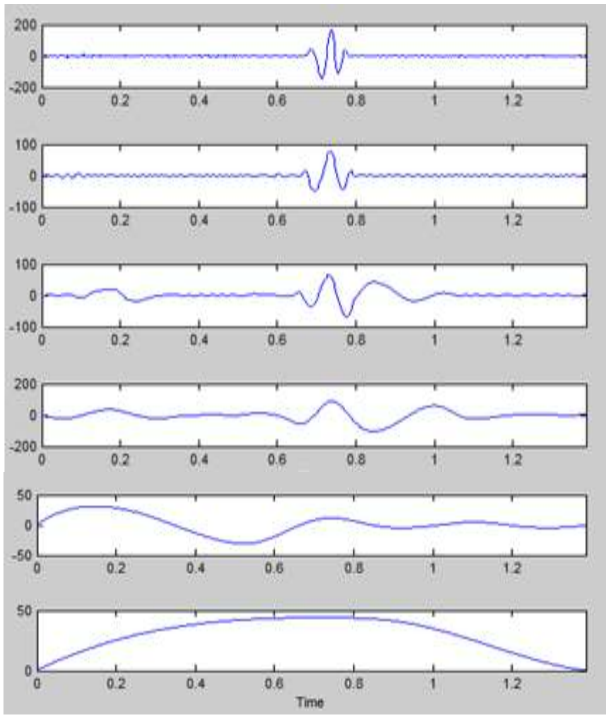

Fig.7 E**CG** signal decomposition by empirical mode decomposition, and then intrinsic mode function varies steps of decomposed the input ecg signal.

C. ANALYSIS RESULTS

Fig.8 ECG signal analysis results is normal.

VI.CONCLUSION AND FUTURE WORK

Our sole objective of this project was to develop a method for efficient analysis of ECG signal. In this piece of work, we have proposed a novel method of enhancement of ECG signal using Empirical Mode Decomposition. Deviating from other approaches of using EMD, we proposed the use for efficient noise removal with find out the normal or abnormal. We have implemented a number of earlier proposed methods for R peak detection including Hilbert Transform.

We have found that the efficiency in case of new ECG denoising Method based on the recently developed Empirical Mode Decomposition (EMD) is proposed to diagnosis the ECG abnormality on System on Chip Architecture.

Thus our method of signal enhancement and R peak detection using Empirical Mode Decomposition method is a novel, efficient method having less computation time, hence best suited for analysis of ECG signal for clinical purposes.

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