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VLSI Implementation of PPG Signal for Health Monitoring System

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Abstract: Denoising of wavelet represents a common processing step performed in various applications in the field of biomedical engineering. Such applications exposes low SNR. These applications require real time processing along with minimization of power and area. This can be done only by using VLSI implementations. It involves PPG signal which is an biomedical signal. But acquired PPG signal are usually corrupted by noise. Due to a common sparsity constraint on spectral coefficients, this method can easily identify and remove spectral peaks of motion artifact in PPG spectra. Xilinx system generator is used for the design of the architecture and simulation of proposed denoising scheme.

Introduction

Digital Signal Processing (DSP) has been increasing in popularly known due to the declining cost of general purpose computers and Application Specific hardware. Since telephony and data communications applications have been moving to digital, the need for digital filtering methods continues to grow. Along with the advancement in Very Large Scale Integration (VLSI) technology and the DSP has become increasingly popular over the years, the fast in realization of FIR digital filters with less power consumption has become much more demanding. Since the complexity of implementation in fir filters are growing with the filter order and the precision of computation, real-time realization of these filters with accuracy is a challenging task.

Related works

Photoplethysmography-Based Heart Rate Monitoring in Physical Activities via Joint Sparse Spectrum Reconstruction. This deals with the Wearable Health Monitoring.

Then VLSI Wavelet Based De-noising of PPG Signal performs using Wavelet transform.

In this Real-time implementation of discrete wavelet transform on FPGA deals with Wavelet transform, hardware implementation.

In 2013, A comprehensive survey of wearable and wireless ECG monitoring systems for older adults is processed by using Signal Recovery, Compressed Sensing.

Signal processing in VLSI

The main aim of this process is extracting the information and then converting into physiological measurement. To diagnosis,monitor and interact with patient in real time it need wearable or implantable electronics devices. By using CMOS technology it is made possible. But it will be consuming more power. To overcome this power consumption, application specific integrated circuit are introduced. But the designing of application specific integrated circuit architecture is complex.

Existing system

The disadvantages of existing system are follows as

High power consumption due to not using of specific filters to processing of medical signals. Complexity is very more when it is implanted in hardware medical applications. Designing and implementation of circuits are difficult. Replacement of device is difficult since components are costly. Then transportation of equipments are not possible. Only few diseases are examined.

Wavelet Transform

This Discrete wavelet transform can be implemented in nine levels. In this method only three levels of transform are implemented. This implementation is scalable. This scalable property is used for scaling of different filter length and additional level also.

$W(p,q)=\int_{-\infty}^{\infty} x(t)\varphi\, p,q(t)\, dt$

$$\varphi\, p,q(t) = 1\frac{1}{\sqrt{p}}\varphi * (\frac{t-q}{p})$$

here

*= complex conjugate

φp,q(t) = window function

To utilize the advantages of systolic processing, several algorithms and architectures have been suggested for systolization of FIR filters. However, the multipliers in these structures require a large portion of the chip-area, and consequently enforce limitation on the maximum possible number of Processing Elements (PE's) that can be

accommodated and the highest order of the filter that can be realized. As the scaling of silicon devices has progressed over the past four decades, semiconductor memory has become cheaper, faster and more efficient.

wavelet transform has very wide range of applications in engineering, science and mathematics.

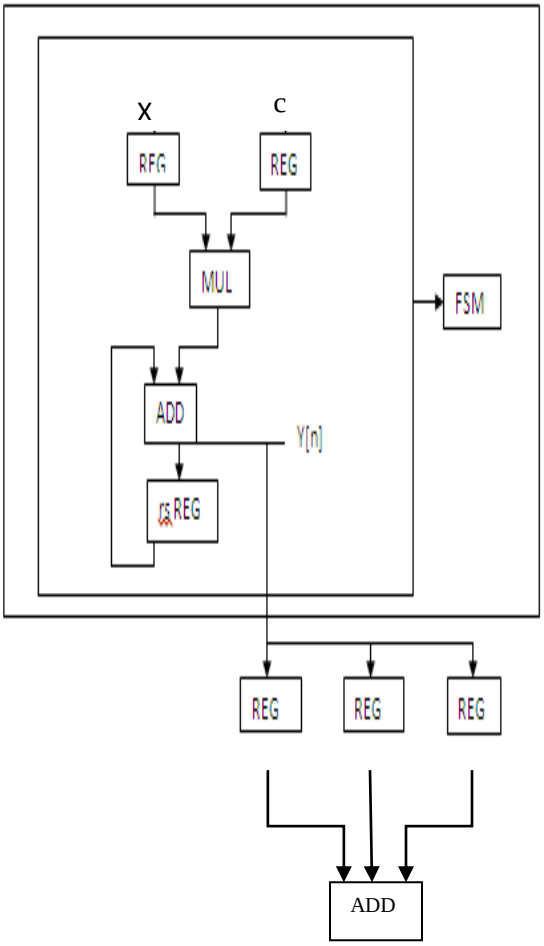


Fig.1 Proposed system architecture which acts as high and low pass section

Adaptive filters are widely used in several digital signal processing (DSP) applications. The tap-delay line finite impulse response (FIR) filters whose weights are updated by the famous Windrow-Hoff least mean square (LMS) algorithm is the most popularly used adaptive filter not only due to its simplicity but also due to its satisfactory convergence performance.

The direct form FIR filter configuration for the implementation of LMS adaptive filter results in either zero or lower adaptation-delay but involves a large critical path due to an inner-product computation to obtain the filter output. Therefore, when the input signal has high sample-rate, the critical-path could exceed the sample period. In such cases, it is necessary to reduce the critical-path by pipelined implementation.

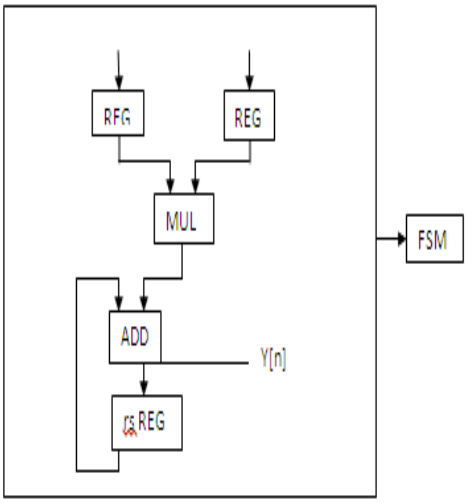
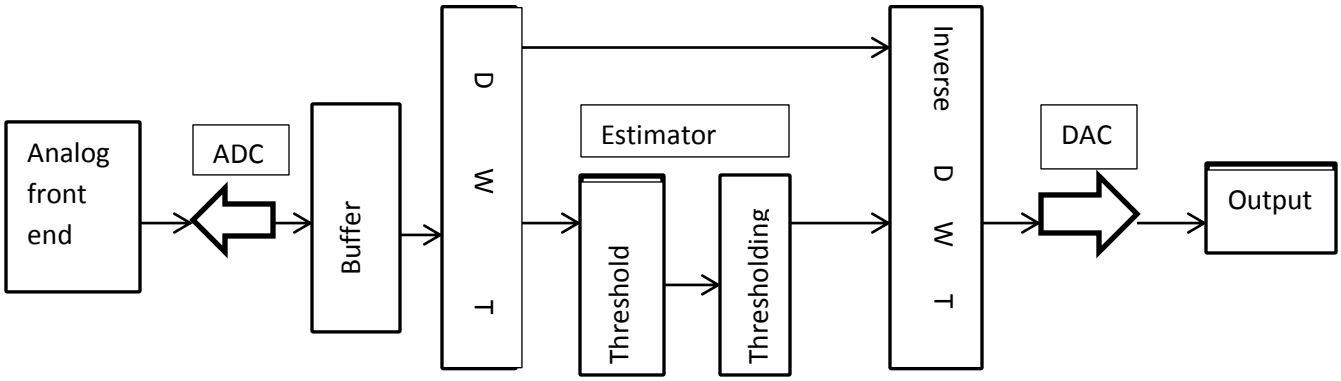


Fig.2 proposed fir filters

Denoising architecture



VLSI tools

This can be designed by using hardware description language. Xilinx system generator for DSP is high level software tools it use matlab to develop the hardware design for Xilinx FPGA. by using this type of tools we can achieve greater performance such as reducing the area, reduction in power consumption and less complexity.

This process is used for denoising of signal in real time. DWT is one of the successful method used in filtering of the signal. This is known as denoising. It consists of four steps. They are signal decomposition, threshold estimation, thresholding and signal reconstruction.

PPG Signal

PPG Signal means photoplethysmography signal which is used for wide range of medical applications such as arthritis diagnosis, detection of diabetes and for various heart beat rate monitors. This signal is used for monitoring physical activities via joint space spectrum reconstruction. Spectrum reconstruction is also known as signal reconstruction.

On comparing with many common sparsity constraint on the spectral coefficient identifying and removing spectral peaks of MA in PPG signal spectra is easy. Hence, it does not need an extra signal processing stage to remove MA as in other signals. Since for a common sparsity constraint on spectral coefficients. This method is used.

This works well for data sampled at low sampling rate thus saving energy consumption in the data acquisition and wireless transmission. By using VLSI implementation in PPG signal of health care monitoring system, low power consumption can be done.

There are various method to estimate Photoplethysmography signal in that estimating spectra of ppg signals and simultaneous acceleration of signals, utilizing the multiple measurement vector model in sparse signal recovery.

Several attempts have, therefore, been made to develop dedicated and reconfigurable architectures for realization of FIR filters in Application Specific Integrated Circuits (ASIC) and Field-Programmable Gate Arrays (FPGA) platforms. Systolic design architectures represent an efficient hardware implementation for computation intensive DSP applications because of its features like simplicity, regularity and modularity of structure. In addition, they also possess significant potential to yield high-throughput rate by exploiting high-level of concurrency using pipelining or parallel processing or both.

The conventional Finite Impulse Response filters use multipliers, adders and delay elements to produce the required output. The multipliers which multiplies input with the fixed content significantly occupies more place to store their temporary values and also increases the power consumption .So, these multipliers are replaced with memory based structures to reduce area and also to reduce the system latency. Several architectures have been reported for memory-based implementation of discrete sinusoidal transforms and digital filters for Digital Signal Processing Applications.

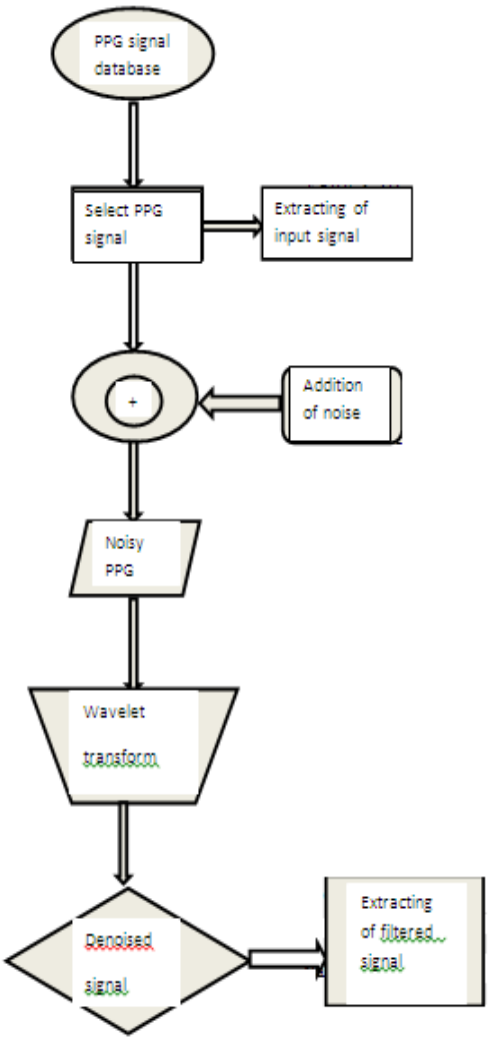
One of the memory based technique is Distributed Arithmetic (DA). In FIR filters, the multipliers are replaced with the multiplier less Distributed Arithmetic (DA)-based technique and it has gained popularity, for its high-throughput processing capability and increased regularity which results in cost-effective and area-time efficient computing structures. The DA based technique consists of Look Up Table, shift registers and scaling accumulator.

Each product term consists of a variable (signal) and a constant (coefficient) both in fixed point binary format but not necessarily of the same word length; Rather than compute the product on a term by term basis. These partial product filter coefficients of all terms are cumulated on bit by bit basis .Finally all the cumulative partial products of each bit are added and the result is produced.

Filters are a basic component of all signal processing and telecommunication systems. Filters are widely employed in signal processing and communication systems in applications such as channel equalization, noise reduction, radar, audio processing, video processing, biomedical signal processing, and analysis of economic and

financial data. For example in a radio receiver band-pass filters, or tuners, are used to extract the signals from a radio channel. Digital Filters are divided into two categories, including Finite Impulse Response (FIR) and Infinite Impulse Response (IIR). And FIR filters are widely applied to a variety of digital signal processing areas for the virtues of providing linear phase and system stability. Finite impulse response (FIR) filters are the most popular type of filters implemented in software.

Process of denoising signal:



This technique uses Xilinx system generator which contains low pass filter and high pass filters for decomposition at each levels. In second level of wavelet transform, the suitable thresholding techniques are applied in reconstruction. The specification for filters are given by values of their coefficient and this values can be floating point. It can be differ in vector lengths. Types based on vector lengths are Haar, Coif1 WT and Daubechies. In this Haar is simplest to one quadratic spline. Daubechies is complex than Haar.

The proposed architecture using Xilinx system generator equalizes the filter path delay by using delay operators. In this process Wavelet decomposition and wavelet reconstruction are carried out, results are obtained.

FIR Filters

A digital filter uses a digital processor to perform numerical calculations on sampled values of the signal. The processor may be a general purpose computer such as a PC, or a specialized DSP (Digital Signal Processor) chip. Digital filters are used in a wide variety of signal processing applications, such as spectrum analysis, digital image processing, and pattern recognition. Digital filters eliminate a number of problems associated with their classical analog counterparts and thus are preferably used in place of analog filters.

The analog input signal must first be sampled and digitized using an ADC (analog to digital converter). The resulting binary numbers, representing successive sampled values of the input signal, are transferred to the processor, which carries out numerical calculations on them. Fast DSP processors can handle complex combinations of filters in parallel or cascade (series), making the hardware requirements relatively simple and compact in comparison with the equivalent analog circuitry.

Filtering process of signal

This process is used for denoising of signal in real time. DWT is one of the successful method used in filtering of the signal. This is known as denoising.

It consists of four steps. They are signal decomposition, threshold estimation, thresholding and signal reconstruction. Filtering process is done by using FIR filter. This is done in the first module By using xilinix software version 13.1 filtering process is carried out

Thresholding process

Threshold of an signal can be calculated by using different techniques. In that simplest techniques are used. Several methods for calculating the thresholds of an signal is avoided due to the robustness such as presence of outliners, usually the preferred method is used to estimate σ by the median absolute derivation.

The equation to estimate median absolute derivation is given by

$$MAD = median_i(|X_i - median_j(X_j)|)$$

It is common to implement the mean absolute derivation as simple as of median of the absolute value of the detail coefficient.

Due to the high pass nature of photoplethysmography signal, median absolute value is given by

$$MAD\ ' = median_j(|X_j|)$$

Here

MAD = median absolute deviation

Approximately $MAD = 0.6745\sigma$

Soft thresholding function is performed by using this equation

$$T\tau(Xj) = \begin{cases} xJ - \tau & if\ xj > \tau \\ xj + \tau & if\ xj < -\tau \\ 0 & if|xj| <= \tau \end{cases}$$

Here

τ=>0 is threshold value of the signal

Xj = wavelet coefficient to be thresholded

This was proposed by Donoho and Johnstone.

The data set of standard derivation for mean absolute derivation is obtained by using the equation.

Mean absolute deviation = $\frac{1}{n}\sum_{i=1}^{n}(|ei|)$

ei is given as

ei = x(i) original ppg signal- x(i) denoisedppg signal

Here

x(i) original ppg signal = amplitude of the ppg signal before denoising.

x(i) denoisedppg signal= amplitude of ppg signal after denoising.

n = total number of points in the data set or total number of samples in ppg signal.

Conclusion

The power line from the photoplethysymography signal is removed by using a real time VLSI wavelet transform based on denoising technique. In this Xilinx system generator for dsp is exploited for the implementation and fast prototyping of the proposed system. Several wavelet functions from the wavelet transform are selected for denoising the signal. Since it can be used for comparing ppg signal. Advanced analyzing of ppg signal will be giving the information about blood pressure level, diabetes, arthritis, heart beat rate and cancer.

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