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High Frequency Electromyogram Noise Removal from Electrocardiogram Using FIR Low Pass Filter Based On FPGA

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Abstract

With improvements in capacity and performance and a decrease in cost, FPGAs have become a viable solution for making custom chips and programmable DSP devices. This paper presents an efficient implementation of Finite Impulse Response Filter (FIR) using Distributed Arithmetic (DA) architecture based on FPGA with the help of Xilinx system generator software. Here, the multipliers in FIR filter are replaced with multiplier less DA based technique to remove high frequency Electrocardiogram (EMG) noise from ECG signal. As digital filters plays very significant role in the analysis of the low frequency components in Electrocardiogram (ECG) signal. The ECG is susceptible to noise and it is essential to remove the noise to support decision making for specialist and automatic heart disorder diagnosis systems. We proposed that the signals under experiment has been added with muscle noise and after applying different FIR method, the signals according to signal noise ratio (SNR) and MSE(mean square error) are evaluated. It introduces an effective technique for the denoising of ECG signals corrupted by High frequency muscles contraction noise. The performances of the system were evaluated using the Massachusetts Institute of Technology University and Beth Israel Hospital (MIT-BIH) database. Muscle noise is taken from MIT-BIH noise stress database .Simulation results shows that High frequency EMG noise from ECG was removed effectively by using FIR low pass filter. The implementation is done on a Xilinx chip of Spartan 3E XC3S500e-4fg320 using Xilinx system generator 10.1 with Matlab version7.4.0 (2007a).

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Keywords: ECG, EMG, MATLAB, MIT-BIH database, FPGA, DA- FIR.

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1. Introduction

The heart is comprised of muscle that is rhythmically driven to contract and relax to drive the circulation of blood throughout the body; this electrical activity of the heart can be measured by Electrocardiogram (ECG). It is one of the most important physiological parameter, which is being used at considerable extent for knowing the state of cardiac patients. The major concern of biomedical signal processing is the extraction of pure cardio-logical signals from noisy measurements. The content and accuracy of information extracted from a recording require proper characterization of waveform morphologies, which require the preservation of the phase and amplitude important clinical features and high attenuation of noise [1]. ECG signals are usually corrupted with undesired interference such as electrode artefacts, muscle noise, line noise, and respiration, power line, base line [2, 3, 4]. The frequency range of ECG signal lies between 0.05-100 Hz and voltage levels of 0.5-4mV. EMG noise is one of the major noise having frequency range varies from 1-10000Hz and voltage levels of 0.1-10mV, depending upon the muscle movement rate and pressure on it. Thus EMG signal causes distortion of ECG signal and induces random noise in it. The spectrum of EMG signals overlap the spectrum of ECG signals and hence it is hard to distinguish the peaks of ECG signal and peaks of noisy signal induced by patient's movement. The presence of undesired interferences cause serious problem in the ECG diagnosis [5].

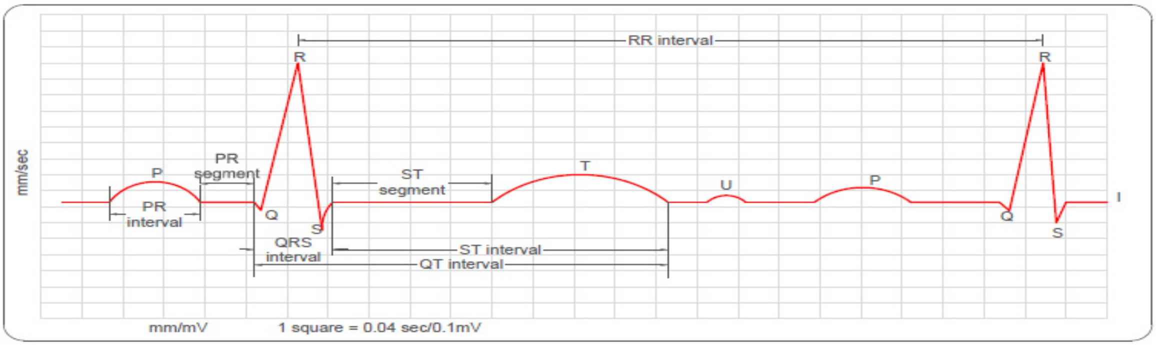

Fig.1. Pure ECG signal [1]

Many methods were proposed in the past for the removal of Electromyogram interference in the ECG. P Raphisak, SC Schuckers, A de Jongh Curry et al. [6] suggested an automated algorithm for detecting EMG noise in large ECG data. The algorithm extracts EMG artifact from the ECG by using a morphological filter. Rakesh Chand, Pawan Tripathi, Abhishek Mathur et al. [7] shows implementation of fast FIR low pass filter for EMG removal from ECG signal. They designed the architecture having less critical delay than convention FIR design and fast enough to remove EMG from ECG signal. They used branched tree architecture for adder connection to reduce the critical delay. Castillala Mancha et al. [8] use neural network to remove Muscular and Artefacts Noise from the Electrocardiogram (ECG). As the result, we are careful while removing the EMG noise so that we do not eliminate vital components of the ECG signal [9]. Finite impulse response (FIR) digital filters are commonly used components in many digital signal processing (DSP) systems. Throughout the years, with the increasing development in very large scale integration (VLSI) technology, the real time realization of FIR filter with less hardware essential and less latency has become more and more important. As the complications of implementation extends with the length of filter, various algorithms have been mapped into effective architectures using ASIC's and FPGA's; one of them being distributed arithmetic (DA).The main portion of DA-based computation is lookup table (LUT) which stores the pre computed values and can be read out easily, which makes DA-based computation well suited for FPGA realization, because the LUT is the basic component of FPGA.[10] Fig. 1 shows an example of normal ECG trace, which consists of P wave, QRS complex and T wave. The small U wave may also be sometimes visible. P wave generates the sequential depolarization of right and left atria. Depolarization of right and left ventricular produces QRS complex and T wave will be form by repolarization of ventricular.PR interval represents the duration of the conduction through the atria to the ventricles. The PR segment represents the duration of conduction from AV node