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Research Article

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Design and implementation of digital filters in mobile health-care applications.

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Keywords

FIR filter,
ECG signal,
android.

Abstract

Digital filtering process is important and necessary to suppress the noisy characteristics embedded in biomedical applications. As the availability and usage levels of mobile android applications increases it will be helpful to view the information in our handheld devices. For these aspects ECG signal transmitted to mobile to provide a sequential healthcare monitoring. However these signals have more noises due to base-line and power-line drifts. With this aim, finite impulse response algorithms are implemented with an android platform smartphone to eliminate the noisy components especially in the ECG signal. Graphical User Interface (GUI) is designed and implemented in an Android OS smartphone with various windowing techniques such as hamming, hanning, blackman, rectangular, kaiser. Each windowing functions provide different information about the input.

1. Introduction

Android is an operating system. It is used by several smartphones and tablets. Now a day's android mobile phones has become a one of the basic need so it is necessary to get all the information in our handheld devices. This paper build an android app where the information about the ECG signal can be get through mobiles by applying digital filter. By applying digital filter noises are removed and even least mean square filter algorithm is also added to get more clear results. It is often essential to build digital filtering algorithm into the embedded tool to eliminate the noisy disturbance in the ECG signal. The pervasive usage of mobile phones with the sophisticated skills of Information and Communication Technology, a variety of clinical domains has been emerging in terms of telehealth. Along with these aspects of healthcare awareness, mobile telecardiology systems are developed to examine heart conditions especially from the high-risk cardiac patients in the patient-centric manner. To achieve a patient's cardiac surveillance outside of healthcare provider's services, a smart mobile phone is acknowledged as the system to obtain personal electrocardiogram from the low-cost hardware utilizing Bluetooth and multimedia messaging service. Opening of the SMS text message that contains ECG samples, the essential symbols about a heart condition are delivered to a PDA or a smartphone to plot the ECG on its screen. Two-smartphone based wearable ECG recording system is also developed to display the waveforms and to detect abnormal beats by determining the isoelectric region around the QRS and reference position for the P and T features. On the other hand, the usage of a mobile phone as the device to obtain ambulatory data from the wearable ECG monitoring hardware module, the acquired signal with a smartphone is vulnerable to distortion due to poor electrode-skin contact, motion artifacts, power-line interference, or base-line drifting. These noises can induce the false recognition about the ECG fiducially features and may affect the clinical decisions concerning healthcare delivery.

2. Digital filters:

A digital filter is a method that performs mathematical operations on a sampled, discrete time signal to decrease or improve definite aspects of that signal. This is in difference to the other most important type of electronic filter, the analog filter, which is an electronic circuit operating on continuous-time analog signals. A digital filter method usually consists of an analog-to-digital converter to sample the input signal, followed by a microprocessor and some nonessential mechanism such as memory to store data and filter coefficients etc. Lastly a digital-to-analog converts to absolute the output stage. Program commands (software) consecutively on the microprocessor implement the digital filter by performing the essential mathematical operations on the information received from the ADC. In some high concert applications, an FPGA or ASIC is used as an alternative of a general purpose microprocessor, or a particular DSP with definite paralleled architecture for expediting operations such as filtering. Digital filters may be very costly than an equivalent analog filter due to their increased complexity but they construct practical many designs that are impractical as analog filters. While used in the perspective of real-time analog systems, digital filters occasionally have problematic latency (the difference in time between the input and the response) due to the related analog-to-digital and digital-to-analog conversions and anti-aliasing filters or due to other delays in their implementation. Digital filters are routine and an necessary element of everyday electronics such as radios, cell phones, and AV receivers. Mathematical study of the transfer function can explain how it will respond to any input.

Filter design:

An FIR filter is considered by finding the coefficients and filter order to meet definite specifications, which can be in the time-domain. Matched filters achieve a cross-correlation among the input signal and a known pulse-shape. The FIR convolution is a cross-correlation among the input signal and a time-reversed copy of the impulse-response. As a result, the matched-filter's impulse response is "designed" by sampling the known pulse-shape and using those samples in reverse order as the coefficients of the filter.

While a particular frequency response is preferred, numerous different design methods are general:

1. Window design method.
2. Frequency sampling method.
3. Weighted least squares design.
4. Parks-McClellan method. The Remez switch algorithm is commonly worn to find an optimal equiripple set of coefficients. Here the user specifies a desired frequency response, a weighting function for errors from this response, and a filter order *N*. The algorithm then finds the set of {N+1} coefficients that minimize the maximum deviation from the ideal. Intuitively, this finds the filter that is as close as you can get to the desired response given that you can use only {N+1} coefficients. This method is particularly easy in practice since at least one text includes a program that takes the desired filter and *N*, and returns the optimum coefficients.
5. Equiripple FIR filters can be designed using the FFT algorithms as well. The algorithm is iterative in nature. You simply compute the DFT of an initial filter design that you have using the FFT algorithm (if you don't have an initial estimate you can start with h[n]=delta[n]). In the Fourier domain or FFT domain you correct the frequency response according to your desired specs and compute the inverse FFT.

3. Window and their techniques:

The finite impulse response (FIR) filter is one of the most basic elements in a digital signal processing system, and it can guarantee a strict linear phase frequency characteristic with any kind of amplitude frequency characteristic. Besides, the unit impulse response is finite; therefore, FIR filters are stable system. The FIR filter has a broad application in many fields, such as telecommunication, image processing, and so on. Several window function have been proposed. Listed below are some of the most common.

- ✓ Hamming window.
- ✓ Hanning window.
- ✓ Blackman window.
- ✓ Rectangular window.
- ✓ Kaiser window.

Hamming window:

Richard W. hamming observed that the side lobes of the rectangular and HANNING windows are phase reversed relative to each other, so a linear combination of the two would tend to cause them to cancel each other. He searched for the linear combination that minimized the maximum side lobe amplitude and came up with the following formulation, which represents a raised cosine on a rectangular pedestal.

Hanning window:

The Hanning window, after its inventor whose name was Von Hann, has the shape of one cycle of a cosine wave with 1 added to it so it is always positive. The sampled signal values are multiplied by the Hanning function, and the result is shown in the figure. Note that the ends of the time record are forced to zero regardless of what the input signal is doing. While the Hanning window does a good job of forcing the ends to zero, it also adds distortion to the wave form being analyzed in the form of amplitude modulation.

Blackman window:

Blackman windows are defined as: By common convention, the unqualified term Blackman window refers to α = 0.16, as this most closely approximates the "exact Blackman", with a0 = 7938/18608 ≈ 0.42659, a1 = 9240/18608 ≈ 0.49656, and a2 = 1430/18608 ≈ 0.076849.These exact values place zeros at the third and fourth side lobes.

Rectangular window:

The rectangular window is what you would obtain if you were to simply segment a finite portion of the impulse response without any shapping in the time domain.

Kaiser window:

The Kaiser window is an approximation to the prolate-spheroidal window, for which the ratio of the mainlobe energy to the sidelobe energy is maximized. For a Kaiser window of a particular length, the parameter β controls the sidelobe height. For a given β, the sidelobe height is fixed with respect to window length. The statement kaiser (n,beta) computes a length n Kaiser window with parameter beta.

An FIR filter is designed by finding the coefficients and filter order that meet certain specifications, which can be in the time-domain and/or the frequency domain (most common). Matched filters perform a cross-correlation between the input signal and a known pulse-shape.

Rectangular window:

The rectangular window (boxcar or dirichlet window) is the simplest window, equivalent to replacing all but *N* values of a data progression by zeros, making it appear as though the waveform abruptly turns on and off:

$$W(n) = 1$$

4. ECG Signal:

Electrocardiogram (ECG) represents electrical movement of human heart. ECG is combination of 5 waves - P, Q, R, S and T. This signal could be deliberate by electrodes from human body in characteristic engagement. Signals from the electrodes are brought to simple electrical circuits with amplifiers and analog to digital converters. The major problem of digitalized signal is hindrance with other noisy signals like power supply network 50 Hz frequency and breathing muscle artifacts. These noisy elements have to be detached before the signal is used for subsequent data processing like heart rate frequency detection. Digital filters and signal processing should be considered very effective for subsequent real-time applications in embedded devices. Heart rate frequency is extremely significant health status information. The frequency measurement is used in numerous medical or sport applications like stress tests or life treating position prediction. One of probable ways how to get heart rate frequency is work out it from the ECG signal. Heart rate frequency can be detected d from ECG signal by various methods and algorithms. Several algorithms for heart rate finding are based on QRS complex detection and hear rate is computed like distance between QRS complexes. QRS complex can be founded using for example algorithms from the field of artificial neural networks, genetic algorithms, wavelet transforms or filters banks.

Moreover the next way how to detect QRS complex is to use adaptive threshold. The direct methods for heart rate detection are ECG signal spectral analyze and Short-Term Autocorrelation method. Disadvantage of all these methods is their complicated implementation to microprocessor unit for real time heart rate frequency detection. Real time QRS detector and heart rate computing algorithm from resting 24 hours ECG signal for 8-bit microcontroller is described. This algorithm is not designed for physical stress test with artefacts. The designed digital filters and heart rate frequency detection algorithms are very simple but robust. They can be used for ECG signal processing during physical stress test with muscle artefacts. They are suitable for easy implementation in C language to microprocessor unit in embedded device.

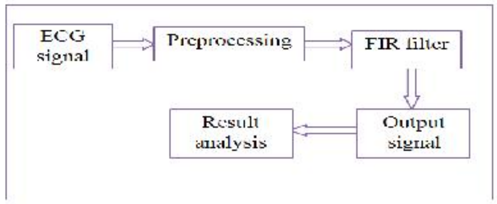

Figure 4.1: Block diagram

The aim of pre-processing is an improvement of the data that suppresses unwanted distortions or enhances some image features important for further dispensation. LMS algorithm gives the accurate result of signal. The output signal will be in wave format and the coefficients of the result analysis will be produced. The aim of pre-processing is an improvement of the data that suppresses unwanted distortions or enhances some image features important for further processing. LMS algorithm gives the accurate result of signal. The output signal will be in wave format and the coefficients of the result analysis will be produced.

5. Android software development:

Android software development is the process by which new applications are created for devices running the Android operating system. Applications are usually developed in Java programming language using the Android software development kit (SDK). Java is object oriented.

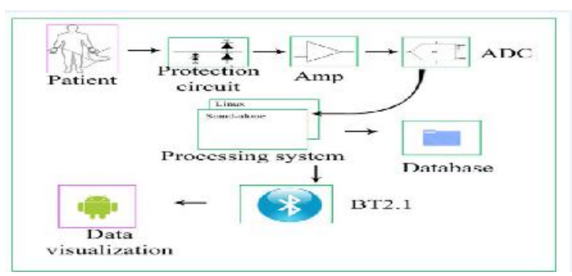

Figure 5.1: ECG signal analysis

Java requires that each variable be initialized. Some older languages such as C, allow variables to go uninitialized, which can cause random failures with mysterious bugs. Java requires that each method that declares a return type, always return a value. This also prevents bugs. Eclipse is an integrated development environment (IDE) used in computer programming, and is the most widely used Java IDE. It contains a base workspace and an extensible plug-in system for customizing the environment.

Unchanged C++ or C code will not work in Java, in most cases, though Java looks much like C and C++. Java can run on many different operating systems. This makes Java platform independent.

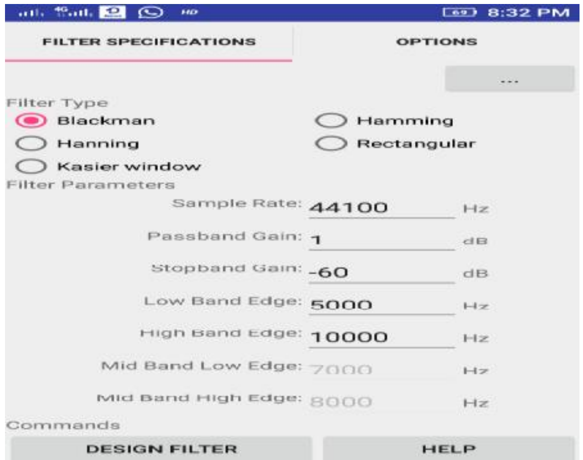

Figure 5.2: Select the input & filter type.

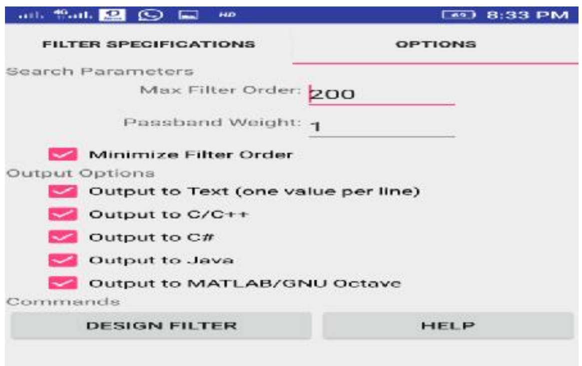

Figure 5.3: Select the output options.

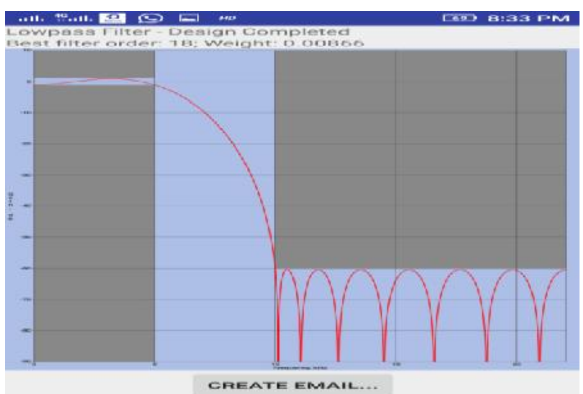

Figure 5.4: Output signal.

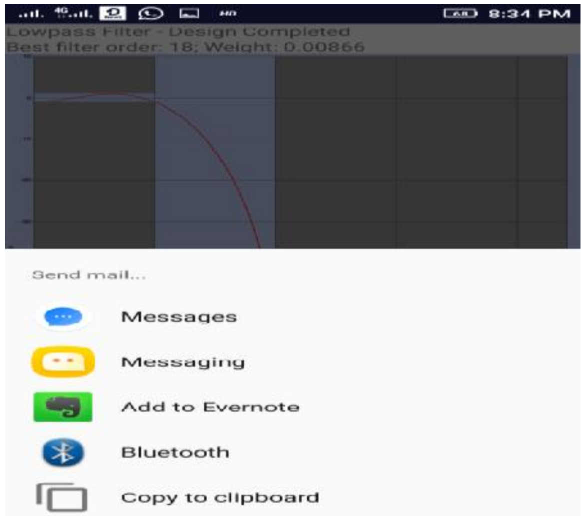

Figure 5.5: Sharing of output signal.

6. Conclusion

With the widespread usage of a mobile device for the pervasive healthcare, it is often necessary to build digital filtering algorithm into the embedded device to eliminate the noisy disturbance in the ECG signal because the distorted characteristics may hinder a healthcare provider from deciding clinical decisions. Thus this research aims at the implementation of a FIR and IIR filter coefficients with an Android platform mobile phone by specifying the required parameters with graphical user interface. From our experimental results, we can conclude that a set of FIR and IIR filter coefficients can be designed and implemented in a mobile device for eliminating baseline fluctuations or power supply interference especially in the ambulatory ECG signal.

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