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H.N. Zaynidinov, S.U. Makhmudjanov

Abstract— Wireless health care monitoring technologies have the energetic to replace our lifestyle with various application uses in the field of such as healthcare management, retailer, travels, company, dependents care and urgent management, in addition to many area for improving. Electrocardiography (ECG) is a common technique for recording the electrical activity of human heart. Accurate computer analysis of ECG signal is challenging, as it is exceedingly prone to high frequency noise and various other artifacts due to its low amplitude. The accuracy of these algorithms relies on the low-pass and high-pass filtration of the input ECG signal. In this paper, it is analyzed various methods for removing the high and low frequency noise components from the ECG signal and evaluate the performance of several adaptive filtering algorithms. Then, sending all experimental information via Bluetooth technology to laptop and real time monitoring.

Keywords: Electrocardiogram; Bluetooth; electromyography; adaptive filter; Amplifier, low-pass filter, high-pass filter, band-pass filter, EGG.

INTRODUCTION

The rapid advancement in the fields of electronic, communication technologies, and new developments in computational algorithms such as deep learning and big data analysis have resulted in new ways of providing health care [1]. Smaller electronic gadgets connected with personal computers, laptops and smart phones have replaced the bulky medical apparatus. For example, the company Bio Telemetry, Inc., [2] offers remote healthcare services to over one million patients over the internet [3]. One of the key components of the computerized remote health care systems is the automatic analysis and understanding of ECG signal by advanced computer algorithms.

Signals play a major role daily life, examples of signals that we encounter frequently are speech, music, picture and video signals. A signal is a function of independent variables such as time, distance, position, temperature, pressure and other physical parameters. For example in an electrical system the associated signals are electric current and voltage[5,6,12,13,14]. In mechanical system the associated signals may be force, speed, torque, etc. A signal can be represented in a number of ways. Most of the signals that we come across are generated naturally. However, some signals are generated synthetically. In generally a signal carries information and objective of signal processing is to extract this information. Signal processing is a method extracting information from the signal that in turn depends on the type of signal and the nature of information it carries. Thus, signal processing is concerned with representing signals in mathematical terms and extracting the information by carrying out the algorithmic operation on the signal[10,11,12].

The accuracy of the analysis usually depends on the quality of the input ECG signal. The recorded ECG signal has low amplitude and is often contaminated with multiple types of noises such as power line interference (PLI), electro surgical noise, lead wire problems, base-line drift and high frequency noise components [4]. Several signal filtering methods exists in the literature to remove specific types of noise component from the ECG signal to improve its SNR. In this paper, it is performed a comparative evaluation of four basic types of filtering methods including Least Mean Square (LMS), Normalized LMS (NLMS), Log LMS, and Sign LMS for ECG signal enhancement and remove the high frequency noise from the ECG signal. The high frequency is generated due to electromyography (EMG) and instrumentation noise. We perform detailed experiments on the ECG signals provided by the MITDB [5] database and compare the performance in terms of the SNR, convergence rate and computational complexity of these algorithms. Our analysis shows that the performance of NLMS is superior than the other adaptive methods in terms of SNR and Sign LMS is computationally efficient. These results can help us in choosing the appropriate filter for ECG signal enhancement and automatic ECG analysis.

DESIGNING AND OVERVIEW OF EGG MEASURING DEVICE

Electrocardiographs detect the electrical signals associated with cardiac activity and produce an ECG, a graphic record of the voltage versus time. They are used to diagnose and assist in treating some types of heart disease and arrhythmias, determine a patient's response to drug therapy, and reveal trends or changes in heart function. Multichannel electrocardiographs record signals from two or more leads simultaneously and are frequently used in place of single-channel units. Some electrocardiographs can perform automatic measurement and interpretation of the ECG as a selectable or optional feature.

ECG units consist of the ECG unit, electrodes, and cables. The 12-lead system includes three different types of leads: bipolar, augmented or unipolar, and precordial.

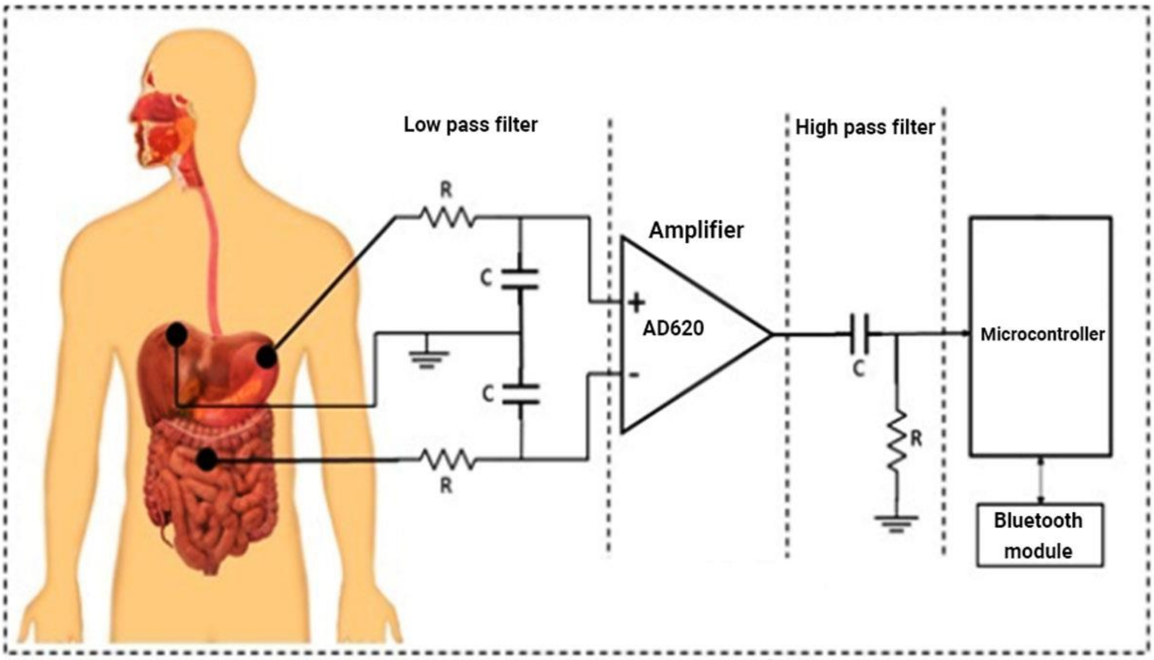

Figure 1. Circuit diagram of EGG measuring device

Each of the 12 standard leads presents a different perspective of the heart's electrical activity; producing ECG waveforms in which the P waves, QRS complex, and T waves vary in amplitude and polarity. Single-channel ECGs record the electric signals from only one lead configuration at a time, although they may receive electric signals from as many as 12 leads. Noninterpretive multichannel electrocardiographs only record the electric signals from the electrodes (leads) and do not use any internal procedure for their interpretation. Interpretive multichannel electrocardiographs acquire and analyze the electrical signals.

MATHEMATICAL EXPLANATION OF FILTERS USED IN THE DEVICE

Low-pass filter

According to Kirchhoff's laws and capacitance tariff, the performance of a simple RC low-pass filter in discrete time is the moving average formula for weight by exponent:

$$y_i = \alpha x_i + (1-\alpha) y_{i-1} \quad (1.1)$$

Where $\alpha := \frac{\Delta_T}{RC + \Delta_T}$

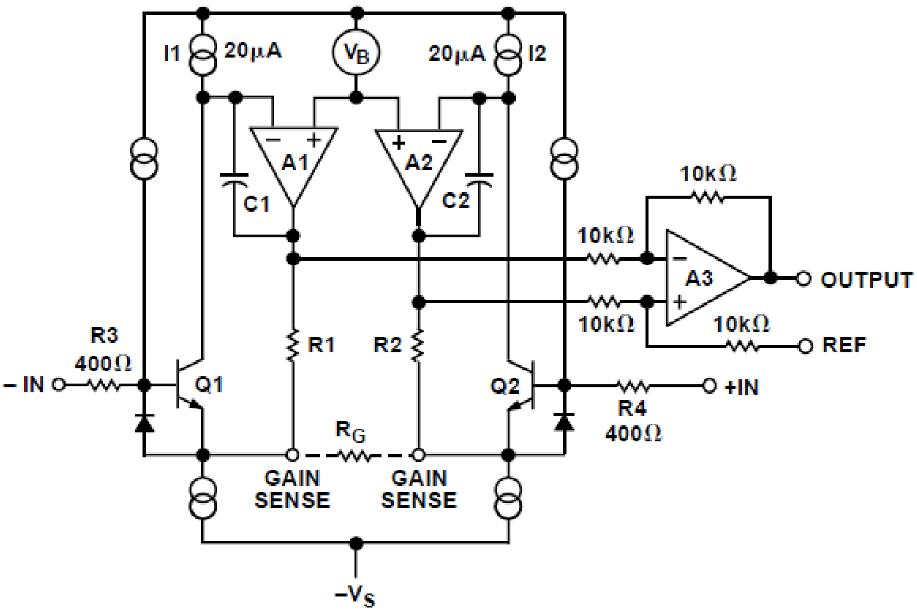

Figure. 2. Simplified schematic of AD620

According to the tariff, the alignment coefficient is 0 <= α <= 1. The expression sample period for α gives an RC value equal to the equivalent time in terms of Δ_T and the alignment factor α :

$$RC = \Delta_T (\frac{1-\alpha}{\alpha}) \quad (1.2)$$

If α = 0.5, then the time constant RC is equal to the sampling period. If α << 0.5, then RC is much larger than the sampling range and Δ_T = α RC.
The iteration rate of the filter provides a method for determining the output samples in terms of input samples and previous output.

AD620 Amplefier
The AD620 is a monolithic instrumentation amplifier based on a modification of the classic three-op amp approach. Absolute value trimming allows the user to program gain accurately (to 0.15% at G = 100) with only one resistor. Monolithic construction and laser wafer trimming allow the tight matching and tracking of circuit components, thus ensuring the high level of performance inherent in this circuit.

The input transistors Q1 and Q2 provide a single differentialpair bipolar input for high precision (Figure 33), yet offer 10´ lower Input Bias Current thanks to Superbeta processing. Feedback through the Q1-A1-R1 loop and the Q2-A2-R2 loop maintains constant collector current of the input devices Q1, Q2 thereby impressing the input voltage across the external gain setting resistor RG. This creates a differential gain from the inputs to the A1/A2 outputs given by G = (R1 + R2)/RG + 1. The unity-gain subtracter A3 removes any common-mode signal, yielding a single-ended output referred to the REF pin potential.

The value of RG also determines the transconductance of the preamp stage. As RG is reduced for larger gains, the transconductance increases asymptotically to that of the input transistors. This has three important advantages: (a) Open-loop gain is boosted for increasing programmed gain, thus reducing gainrelated errors. (b) The gain-bandwidth product (determined by C1, C2 and the preamp transconductance) increases with programmed gain, thus optimizing frequency response. (c) The input voltage noise is reduced to a value of 9 nV/Ö*Hz*, determined mainly by the collector current and base resistance of the input devices.

The internal gain resistors, R1 and R2, are trimmed to an absolute value of 24.7 kW, allowing the gain to be programmed accurately with a single external resistor.

The gain equation is then

$$G = \frac{49.4k\Omega}{R_G} + 1 \quad (1.3)$$

So that

$$R_G = \frac{49.4k\Omega}{G-1} \quad (1.4)$$

High-pass filter

High-frequency filtration also looks like the one described above in low-frequency filtration, except that there is a difference in the overall appearance of the formula.

$$y_i = \alpha y_{i-1} + \alpha(x_i - x_{i-1}) \quad (1.5)$$

Where $\alpha \overset{\Delta}{=} \frac{RC}{RC + \Delta_T}$

Bluetooth transmitter

Based on IoT technology, the patient status monitoring system performs the following tasks step by step. The system Electrogastrography (EGG - Electrogastrography) receives the signal from the human body through a specially designed device using sensors and sends it to a mobile computer (laptop) based on Bluetooth technology.

An electrogastrograph is a sensor device used to measure the electrical potential between different points on the body. We use special electrode technology to receive a standard EGG signal. Depending on how the electrode pairs are connected to the EGG sensor, different frequency and amplitude waveforms can be obtained. Each sensor contains unique information about the activity of the stomach.

Wireless protocol technology used in Bluetooth transmitter. Bluetooth has many advantages. This technology is 10-100 m. allows the exchange of information using remote radio waves. First, it is available in a user-friendly modular form. There are many Bluetooth devices that hide the Bluetooth package and allow the user to communicate with the device using simple modem commands. In addition, Bluetooth is a common technology in mobile phones and it expands the scope of use for the transmitter. HC-06Bluetooth is the device of choice for the wireless module. It has the following options.

The module works based on the Bluetooth 2.0 communication protocol and it only works as a built-in device. It is the easiest way to transfer data wirelessly and is flexible compared to other methods and it can even transfer files at speeds up to 2.1 Mb / s.

The HC-06 uses a frequency bypass spectrum technique (FHSS) to avoid interfering with other devices and to achieve complete two-way transmission. The device operates in the frequency range from 2,402 GHz to 2,480 GHz.

Communication with this HC-06 module is via the UART interface. Data is sent to the module or retrieved from the module via this interface.

There are problems in obtaining experimental data. The reason is that the transmitted EGG signal does not come in the form of a normal frequency (ie Hz).

Maybe the device transmits it in binary view. Also, the transmitted electrical signal does not have a value of "-". It follows that the signal needs to be read and adapted for digital processing. The reading algorithm in above Figure was used for adaptation.

SIMULATION RESULTS

After hardware and software implementation of the system, results are obtained and can be visualized on application. The proposed system can monitor, diagnose, and advice the patients all the time. The health parameters data are stored and published online and offline.

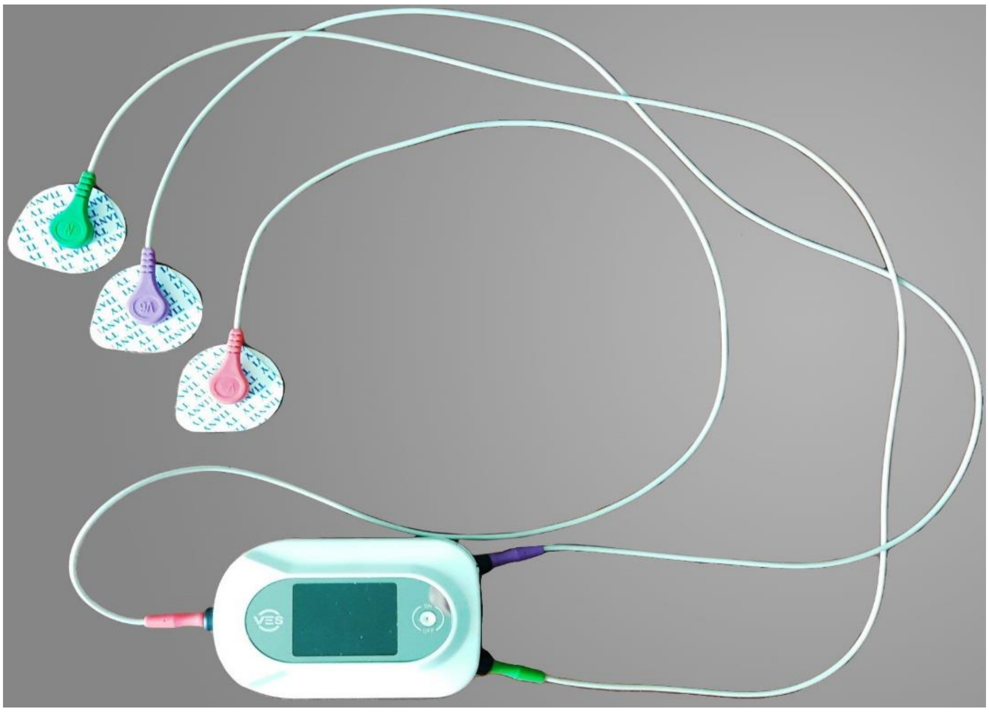

Figure 1. Circuit diagram of EGG measuring device

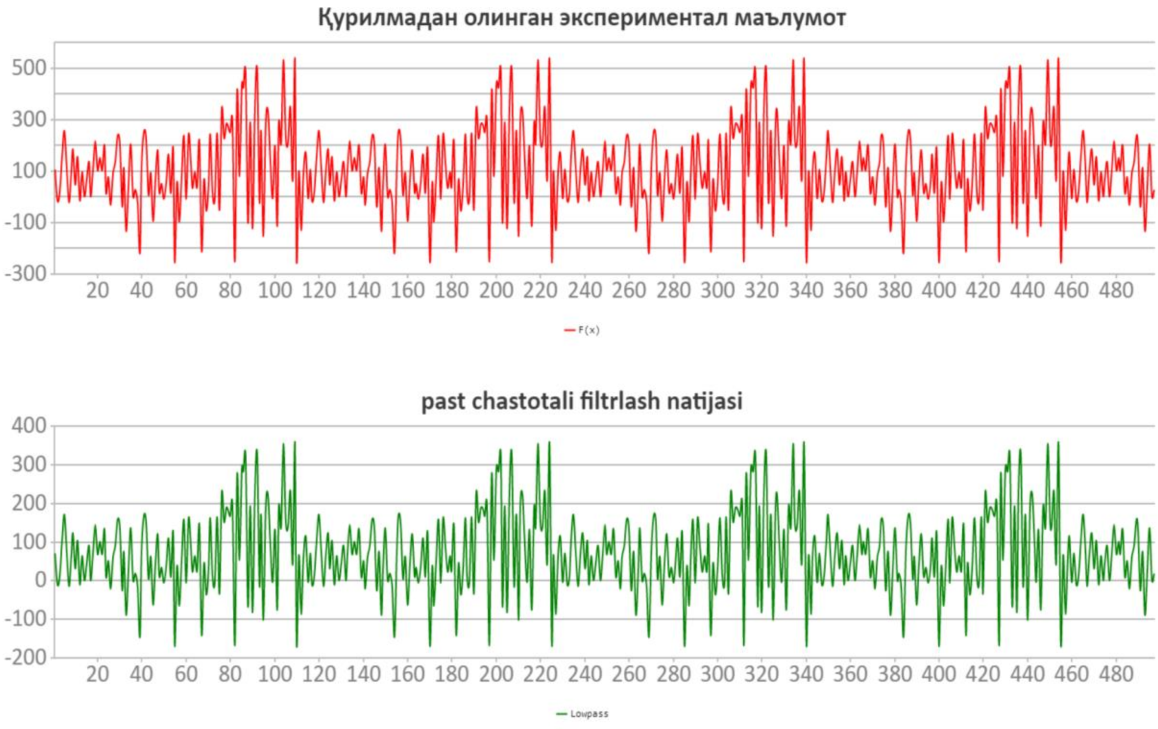

Figure 3. The result of low frequency filtering of the gastroenterological signal

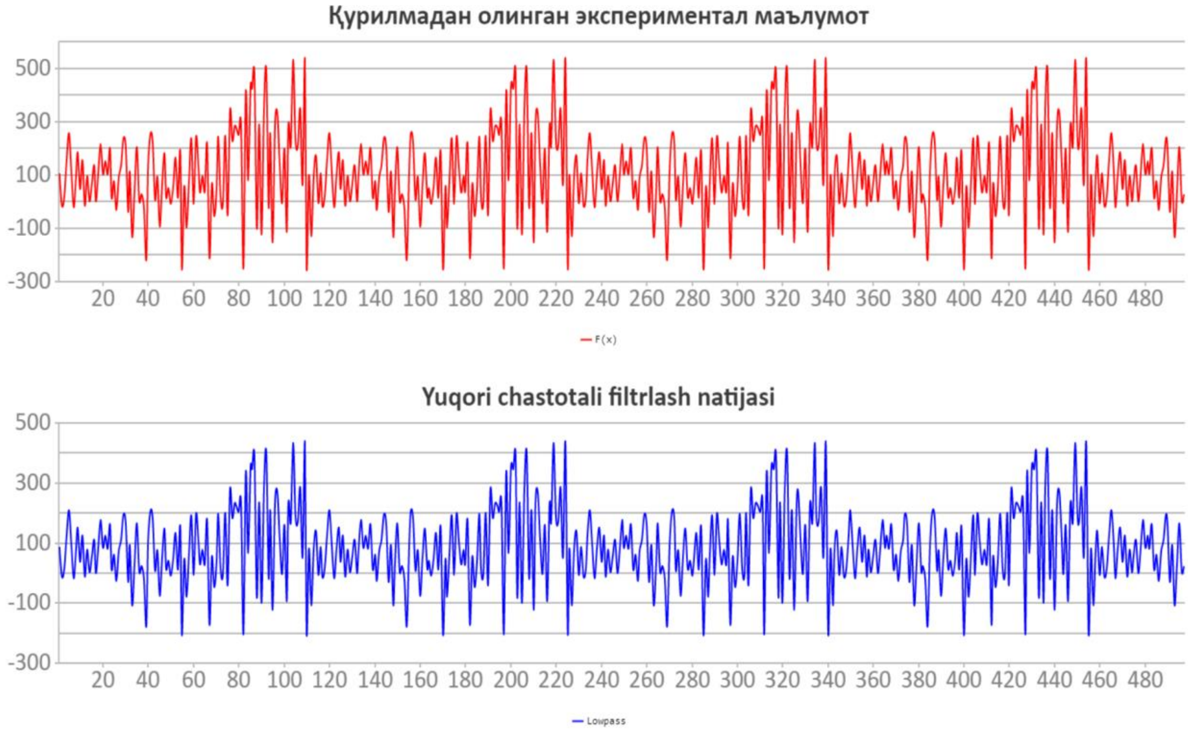

Figure 3. The result of high frequency filtering of the gastroenterological signal

The importance of filtering digital signals is as follows:

1. A device (simple electrical circuit) or program used to perform filtering. The filter divides the input signals or data stream into several desired components.
2. A program that receives, processes, and then retrieves certain types of access data. For example, a sorting program is a filter. It receives signals in unsorted form, then sorts them and gives them to the user in a sorted form.

Data selection condition. The filter only outputs data that satisfies the given conditions.

CONCLUSION

Remote health-care systems are becoming increasingly popular that provide time efficient treatment and advanced medical services to remote areas using Internet. ECG signal processing is a key module of these systems. We have evaluated four pre-processing algorithms for ECG noise removal.

These techniques can be efficiently utilized to provide a deeper insight of ECG signal processing and can be useful for ECG based remote health systems.

These adaptive algorithms can also be used on other physiological signal such as EEG. Once the signal is de-noised, we can extract the features and train a classifier for automated ECG analysis. In the future it will be interesting to see how deep learning methods can be applied to achieve more significant information from the ECG signal and a complete automated ECG analysis system can be realized.

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