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A Roadmap to Design and Analysis of Wearable ECG Monitoring System

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Abstract: ECG (Electrocardiogram) recognition and monitor are the only way to trace and determine heart Diseases. ECG monitors with features such as portable, wireless, user friendly, low-cost and convenient at home, are necessary . This paper's aim is to investigate wireless Body area network co- operation for human movement tracking and ECG measurements, which are believed to provide patients with easy healthcare for continuous health-monitoring. In addition, taking periodic medical readings at home or in the office will aid physicians to periodically supervise the patient's medical status without having to see the patient. The collected measurement data will be processed using specially designed software, which will help sending a medical record of the patient to an electronic device in the acquisition of the physician. Palm, mobile phone and PC could be acting as display and relay terminals, through which ECG signals would be transmitted to data center which is in the hospital through network.

Keywords: Wearable ECG, Signal Averaging, Baseline Drift, Matched Filtering

I. INTRODUCTION

Electrocardiogram (ECG) is defined as a test that records the electrical activity of heart using electrodes attached to the body. The main aim is to improve the patient's ability to freely move around in a daily routine while being monitored by a wearable system. This new concept has several advantages compared to existing solutions. It is easy to use and requires no technical skills to operate [1]. The ECG is continuously recorded with a built-in automatic alarm detection system, and the system can give early alarm signals based on heartbeat even if the patient is unconscious or unaware of cardiac arrhythmias. We use MATLAB software for real-time data display, and post-processing simulations. Electrocardiogram (ECG) signals show the electrical activity of the heart from a lead that is connected externally to a patient. The raw signal that is obtained needs to be filtered in order to produce a readable ECG. With the addition of filtering, we may also want to increase the resolution of the signal by averaging many waves over a length of time to form one ECG wave which we can read. Things that are important to note in an ECG are the Placement and duration of the Pwave, the QRS complex, the T wave, and the ST segment. [4].

II. LITERATURE SURVEY

The concept of wireless ECG monitoring system is intended for detecting rarely occurrences of cardiac arrhythmias and to follow up critical patients from their home while they are carrying out daily activities. It is easy to use and requires no technical skills to operate. The ECG-sensor is a compact electronic electrode which easily can be replaced by the patient himself. The ECG is continuously recorded with a built-in automatic alarm detection system, and the system can be give early alarm signals even if the patient is unconscious or unaware of cardiac arrhythmias. [1]The general wireless ECG system should include: monitored object (lead lines included), monitor, wireless modules, and mobile phone/PC with GSM/GPRS/CDMA module. GSM/GPRS/CDMA based wireless communications between mobile phone/PC and remote PC in hospital is used to transmit ECG signal to service center such as hospital to get instructions from specialists [2].

Mobile phones are one of the most common devices available with each other and every individual in this world. The recent mobile phones have enough available memory, energy, and processing power. So these advantages of mobile phone technology can be utilized to overcome the constraints of the wireless sensor network technology for transmission processing and buffering of the sensed data.[3]The collected measurement data will be processed using specially designed software, which will help sending a full medical record of the patient to an electronic device in the acquisition of the physician using wireless technology [4].Interpreting data from raw ECG signals can be fairly complicated if the signal is not extracted with care .With a raw ECG signal, we get a noisy signal with a baseline drift. So suitable filters are used to remove these and output noise free signals. [5]

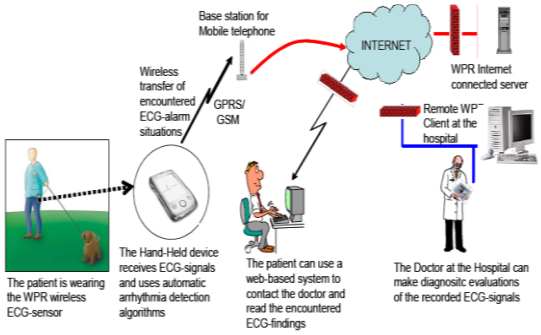

Fig 1. Principle Components of Wireless ECG System [1]

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III. METHODOLOGY

In the measurement setup, we consider different measurements for the arms and legs using sensors. The

1. Measurements from the sensors connected to the wrist and the leg shank
2. Measurements from the sensors connected to the left and right upper arm segments

The used sensors are low-power wireless sensors specially designed for noninvasive biomedical research. It is believed that the measurement of body kinematics and ECG will help to better understand movement artifacts**.** The recorded signals are sent to a receiver integrated as a component within a Hand Held Device (HHD) through wireless transmission which are then uploaded to the cloud for the doctor to refer whenever necessary and This hand held device (mobile phones) uses a standard telecommunication facility, GPRS (General Packet Radio Service), for sending an alarm signal to the server at the doctors end.

Trained personnel will thus be able to evaluate the ECG-recordings, and follow up the patients based on heart beat accordingly.

IV. SIGNAL FILTERING AND AVERAGING

With a raw ECG signal, we get a noisy signal with a baseline drift (voltage not centered around 0V and increases or decreases over time). We desire to uncover the ECG signal behind this noise and drift. To solve this problem, we split the problem into three sub problems as follows [3]

A. Removing Baseline Drift

In order to remove the baseline signal from the original ECG signal, and to remove the baseline drift, a high pass filter is used. It works by cutting out some of the really low frequencies which are responsible for this drift. The standard for the cutoff frequency was .05 Hz, but if a linear phase filter is used, then the cutoff frequency can be increased up to .67 Hz.[5]

The Finite impulse response (FIR) filters are linear phase, but they introduce a time lag since the group delay is a constant. The Infinite impulse response (IIR) filters have nonlinear phase, but the signal can be taken, filtered, and then time reverse the sequence and run it through the filter again. This process creates a zero phase filter, since we have the Negative phase for each frequency, which makes the phase zero for all frequencies. We can also look at the Fourier transform of the ECG signal to see which frequencies are being cut out and attenuated. We then proceeded to fine tune each of the different specifications. For the high pass filter, Matlab code is used.

B. Filtering High Frequency Noises

After filtering the low frequencies, high frequency noise should be reduced. This can be done by designing a linear phase low pass filter. Low pass filter allows the low frequencies to pass through, while attenuating the high frequencies that are due to noise. The standard cutoff frequency was established at 100 Hz, but it was observed that the standard cutoff frequency will smooth too much of the high frequencies, and some of the physiological features will be lost. After looking at the results of the signals that passed through the low pass filter after varying one of the parameters, the best value for each parameter was selected which ensured that the physiological features are preserved? The parameters include cutoff frequency, the amount of attenuation, and the error of the pass band.

Finally, a filter that combines the strict nature of the parameters while not smoothing too much of the physiological features was chosen like the high pass filter, we will also look at the Fourier transform to see which frequencies will be affected.

C. Signal Averaging and Template Matching

There are many different ways to do signal averaging. Matched filtering method is one of the methods. Matched filtering gives us the best tradeoff between simplicity and robustness in the model.

In this method the user is first allowed to identify a template from the signal using the gin put Matlab function. If the user doesn't specify a template, we have a default template region for the signal. After finding the template, the xcorr Matlab function is used to compute the cross correlation. The peaks that resulted in a repetition of a waveform that matched (with minimum error) the template waveform, will give the indices for each of the waveforms. We then proceeded to iterate through the indices and average the resulting signals together. [5]

V. CONCLUSION

There is a gap in the ECG technology that currently doesn't allow for the data leading up to some form of heart failure to be captured. A portable ECG device that is constantly monitoring a patient's heart could not only save their life directly by calling for help in the case of heart failure, it can also save many lives indirectly by providing researchers with data outlining a heart's activity leading up to heart failure.

An algorithm outline has been developed that can read the signal from a portable ECG and perform two main tasks with it. The first is to store the data for in depth analysis in a laboratory later. The second task is to perform some basic dynamic live analysis on the incoming data to determine if the user is experiencing a medical emergency. If this is the case then the smart phone will take appropriate action depending on the severity of the emergency.

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