RESEARCH ARTICLE OPEN ACCESS

Detection of Abnormalities in the Functioning of Heart Using DSP Techniques

CH. Aruna Jyothi[1],P.Anitha[2]

[1] (Assistant Professor, Dept. Electronics & Communication Engineering, Aditya College of Engg & Tech, Kakainada.)

[2](Dept. Electronics & Communication Engineering, Aditya College of Engg & Tech, Kakainada.)

Abstract:

Digital Signal Processing (DSP) Applications have gained great popularity in the study of Bio-Medical Signal Processing .DSP can be used as a tool in the era of Bio-Medical Engineering and it is used to study the continuous rhythmic periodic waveform of ECG and finding out abnormalities present in the function of the heart.DSP solves this task with great accuracy and less complexity. According to available medical research report it has been given to understand the arrhythmias caused due to cardiac abnormalities. In this project we are going to present FFT approaches to analyze the periodic characteristics of ECG waveform and design spectrum of Angina Pectoris of ECG for identifying cardiac abnormalities.

1. INTRODUCTION

Application of signal processing methods, such as filtering, Discrete Fourier Transform (DFT), Fast Fourier transform (FFT) to biomedical problems, such as the analysis of cardiac signals (ECG/EKG).

The signal processing in digital is what we are considering to implement to our ECG signals as an extra function after we finish the basic objective of the project, which is only to design, simulate, fabricate, test, and demonstrate an ECG demonstration board in analog.

DSP Techniques:

Digital signal processing and analog signal processing are subfields of signal processing. DSP applications include audio and speech signal processing, sonar, radar and other sensor array processing, spectral estimation, statistical signal processing, digital statistical signal processing, digital image processing, signal processing for telecommunications, control of systems, biomedical engineering, seismic data processing, among others, Digital signal processing can involve linear or nonlinear operations. Nonlinear signal processing is closely related to nonlinear system identification and can be implemented in the time, frequency, and spatial-temporal domains.

The application of digital computation to signal processing allows for many advantages over analog processing in many applications, such as error detection and correction in transmission as well as data compression. DSP is applicable to both streaming data and static (stored) data.

2. BLOCK DIAGRAM

Normal ECG waveform:

The fundamental component to electrocardiograph is the Instrumentation amplifier, which is responsible for taking the voltage difference between leads (see below) and amplifying the signal. ECG voltages measured across the body are on the order of hundreds of micro volts up to 1 milli volt (the small square on a standard ECG is 100 micro volts). This low voltage necessitates a low noise circuit and instrumentation amplifiers are key.

Early electrocardiographs were constructed with analog electronics and the signal could drive a motor to print the signal on paper. Today, electrocardiographs use analog-to-digital converters to convert to a digital signal that can then be manipulated with digital electronics. This permits digital recording of ECGs and use on computers.

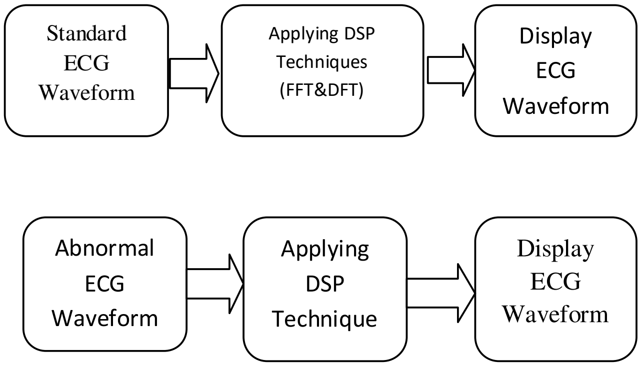

Figure: 2.1: Block Diagram of techniques applied to ECG wave form

Physiological data are displayed continuously on a CRT, LED or LCD screen as data channels along the time axis. They may be accompanied by numerical readouts of computed parameters on the original data, such as maximum, minimum and average values, pulse and respiratory frequencies, and so on.

Besides the tracings of physiological parameters along time (X axis), digital medical displays have automated numeric readouts of the peak and/or average parameters displayed on the screen.

Contraction of the heart muscle occurs in response to electrical depolarisation the rapid spread of electrical activity throughout the myocardium which is facilitated by specialised conduction tissue. This process normally begins with spontaneous depolarisation of cells in the sinus node, situated in the right atrium (RA), then proceeds quickly through the atria to the atrioventricular node, and then down the bundle of His to the left and right bundle branches and into the ventricular myocardium.

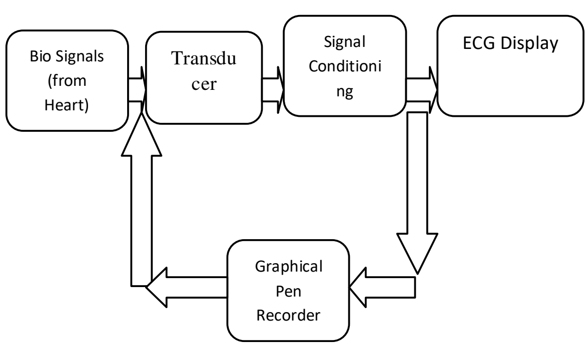

Figure: 2.2 Block diagram of ECG Implementation

Bio signals:

The term bio signal is often used to refer to bioelectrical signals, but it may refer to both electrical and non-electrical signals. The usual understanding is to refer only to time-varying signals, although spatial parameter variations (e.g. the nucleotide sequence determining the genetic code) are sometimes subsumed as well.

Electric bio signals such as EEG and ECG can be measured without electric contact with the skin. This can be applied for example for remote monitoring of brain waves and heart beat of patients who must not be touched, in particular patients with serious burns.

Transducer:

A transducer is a device that converts one form of energy to another. Usually a transducer converts a signal in one form of energy to a signal in another.

Transducers are often employed at the boundaries of automation, measurement, and control systems.

Electrical signals are converted to and from other physical quantities (energy, force, torque, light, motion, position, etc.). The process of converting one form of energy to another is known as transduction

Passive:

Passive sensors require an external power source to operate, which is called an excitation signal. The signal is modulated by the sensor to produce an output signal.

Active:

Active sensors generate electric signals in response to an external stimulus without the need of an additional energy source.

Sensors:

A sensor is a device that receives and responds to a signal or stimulus. Transducer is the other term that is sometimes interchangeably used instead of the term sensor, although there are subtle differences. A transducer is a term that can be used for the definition of many devices such as sensors, actuators, or transistors.

Actuators:

An actuator is a device that is responsible for moving or controlling a mechanism or system. It is operated by a source of energy, which can be mechanical force, electrical current, hydraulic fluid pressure, or pneumatic pressure, and converts that energy into motion.

Graphic recorders are essentially measuring instruments that produce in real-time graphic representations of (biomedical) signals, in the form of a permanent document intended for visual inspection. Recorded data are thus fixed on a two-dimensional (2D) medium that can simply be called "paper". Real-time paper recordings have the benefit of direct visual access to signal information, allow immediate examination (and re-examination) of trends (as long strips of paper can be used), present better graphic quality than most screens and can be used as a document for scientific evidence.

4. ELECTROCARDIOGRAM

An electrocardiograph with integrated display and keyboard on a wheeled cart an electrocardiograph is a machine that is used to perform electrocardiography, and produces the electrocardiogram. The first electrocardiographs are discussed above and are electrically primitive compared to today's machines.

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Electrode Name	Colour	Position	System
RA	White ('snow')	Right arm	3-elctrode 5-electrode 12-lead ECG
LA	Black ('smoke')	Left arm	3-elctrode 5-electrode 12-lead ECG
LL	Red ('fire')	Left leg	3-elctrode 5-electrode 12-lead ECG
RL	Green ('grass')	Right leg	5-electrode 12-lead ECG
C	Brown	Central chest Over sternum	5-electrode
V1	Red	Sternal edge Right 4th ICS	12-lead ECG
V2	Yellow	Sternal edge Left 4th ICS	12-lead ECG
V3	Green	Between V2 and V4	12-lead ECG
V4	Blue	Mid-clavicular line Left 5th ICS	12-lead ECG
V5	Orange	Between V4 and V5 Left 5th ICS	12-lead ECG
V6	Purple	Mid-axillary line Left 5th ICS	12-lead ECG

Table 1: ECG Electrodes

ECG Intervals:

- PR interval.
- PR segment.
- QRS complex.
- QT interval.
- ST segment.
- RR interval.

The PR interval begins at the onset of the P wave and ends at the onset of the QRS complex. This interval represents the time the impulse takes to reach the ventricles from the sinus node.

It is termed the PR interval because the Q wave is frequently absent. Normal values lie between 0.12 and 0.20 seconds.

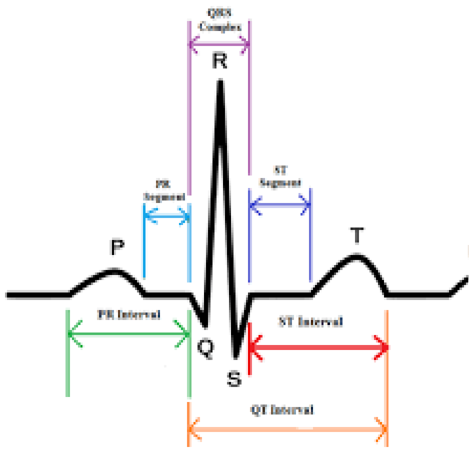

Fig: ECG waveform

The PR segment begins at the endpoint of the P wave and ends at the onset of the QRS complex. It represents the duration of the conduction from the atrioventricular node, down the bundle of His and through the bundle branches to the muscle.

The QRS represents the duration of ventricular depolarisation. Normally all QRS complexes look alike. They are still termed QRS complexes even if all three waves are not visible. The QT interval represents the duration from the depolarisation to the repolarisation of the ventricles. It begins at the onset of the QRS complex and ends at the endpoint of the T wave.

The ST segment begins at the endpoint of the S wave and ends at the onset of the T wave.During the ST segment, the atrial cells are relaxed and the ventricles are contracted so electrical activity is not visible. the ST segment is normally isoelectric.

The RR interval is the time measurement between the R wave of one heartbeat and the R wave of the preceding heart beat. RR intervals are normally regular, but may be irregular with sinus node disease and supra ventricular arrhythmias.

5. DIGITAL SIGNAL PROCESSING

Digital signal processing refers to various techniques for improving the accuracy and reliability of digital communications. The theory behind DSP is quite complex. Digital signal processing (DSP) is the use of digital processing, such as by computers, to perform a wide variety of signal processing operations. The signals processed in this manner are a sequence of numbers that represent samples of a continuous variable in a domain such Basically, DSP works by clarifying, or standardizing, the levels or states of a digital signal". as time, space, or frequency.

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FFT:

An FFT computes the DFT and produces exactly the same result as evaluating the DFT definition directly; the most important difference is that an FFT is much faster. (In the presence of round-off error, many FFT algorithms are also much more accurate than evaluating the DFT definition directly, as discussed below.)

Let x_0, ..., x_{N-1} be complex numbers. The DFT is defined by the formula

$$X_K = \sum_{n}^{N-1} Xn\ e^{-j2\pi kn/N} \qquad K=0,..., N\text{-}1.$$

The power spectrum of a time series describes the distribution of power into frequency components composing that signal. According to Fourier analysis any physical signal can be decomposed into a number of discrete frequencies or a spectrum of frequencies over a continuous range. The statistical average of a certain signal or sort of signal (including noise) as analyzed in terms of its frequency content is called its spectrum.

The average power P of a signal over all time is therefore given by the following time average:

$$P=\lim_{T\to\infty}\frac{1}{T}\int_{-T}^{T}|X(T)|^2\ dt$$

6. MATLAB

MATLAB is a high performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notations.

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non interactive language such as C or FORTRAN.

7. RESULTS

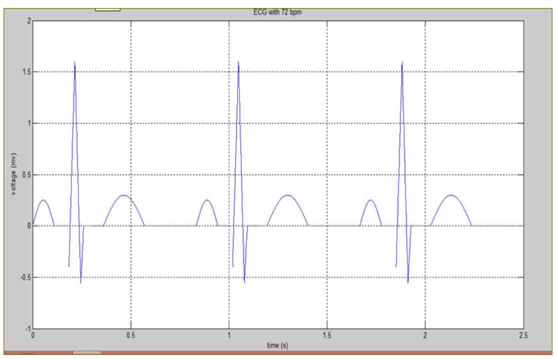

Figure 7.1: Normal ECG output waveform

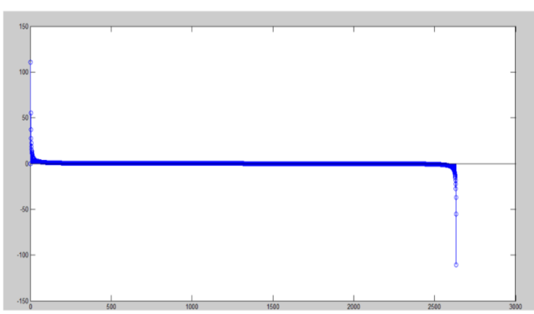

Figure7.2: Normal ECG FFT output

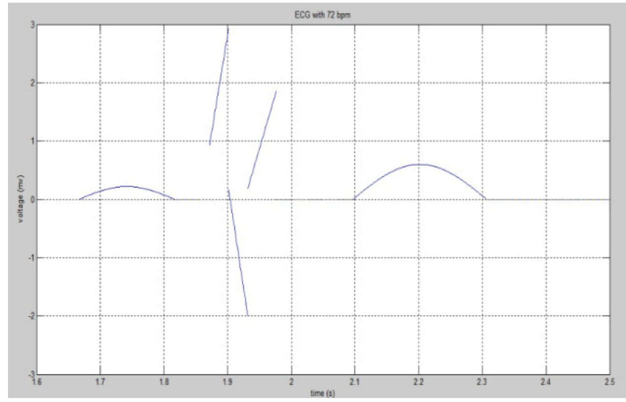

Figure 7.3: Abnormal ECG –Output waveform

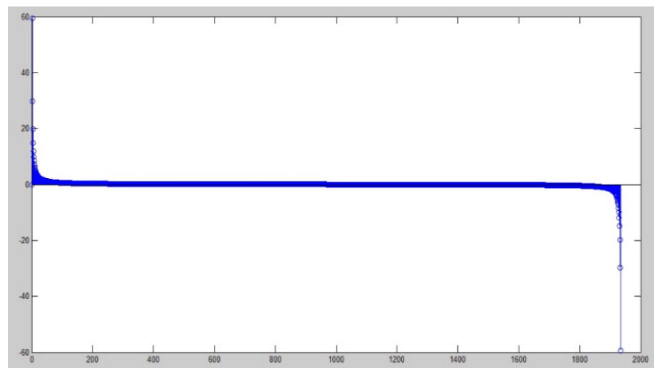

Figure 7.4: Abnormal ECG FFT output

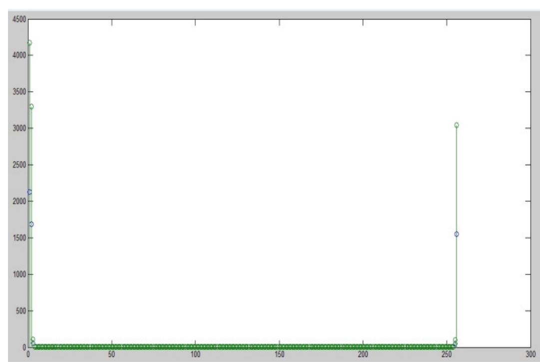

Figure 7.5 : Normal ECG –PSD output waveform

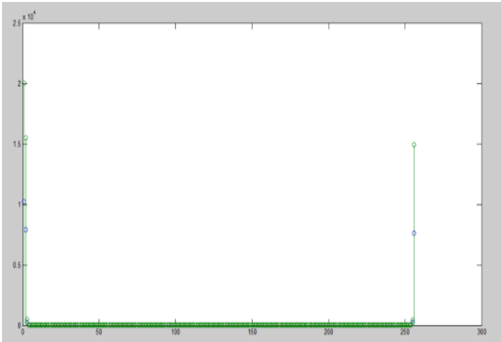

Figure 7.6 : Abnormal ECG –PSD output waveform

CONCLUSION

Hence we find DSP can be used as a tool in the era of Bio-Medical Engineering and it is used to study the continuous rhythmic periodic waveform of ECG and Digital Signal Processing (DSP) Applications are very useful in the study of finding out abnormalities present in the function of the heart. And we prove DSP solves this task with great accuracy and less complexity. In this project we are present DFT approaches to analyze the periodic characteristics of ECG waveform and we describe the spectrum of Angina Pectoris of ECG for identifying cardiac abnormalities.

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