

**MODELLING CARDIAC SIGNAL AS A TOMOGRAPHIC MAP**

by

**NOOR ANIS ATIQA MOHD KHUZI**

**Submitted to the Electrical & Electronics Engineering Programme  
in Partial Fulfilment of the Requirements  
for the Degree  
BACHELOR OF ENGINEERING (Hons)  
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**By**

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# **CERTIFICATION OF APPROVAL**

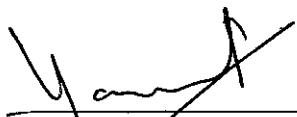
## **MODELLING CARDIAC SIGNAL AS A TOMOGRAPHIC MAP**

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A Project Dissertation submitted to the  
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December 2009

## **CERTIFICATION OF ORIGINALITY**

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



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**NOOR ANIS ATIQA MOHD KHUZI**

## **ABSTRACT**

The interpretation of ECG for medical purpose has become an important issue today. The medical professionals use this interpretation to diagnose the heart disease. As concern, the manual interpretation may not accurate due to the altered of the ECG signal by cardiovascular disease and abnormalities. The main focus of this project is about analyzing ECG signal by using tomography mapping or in the simplest way; colored representation. Based on the research on the characteristics as well as the technical knowledge of MATLAB simulation, this project can developed a better way for ECG interpretation. This project is designed to emphasize the one dimensional ECG to colorful pattern known as tomographic mapping based on the vertical and horizontal surge in amplitude. This report will explain the steps involved in implementing the project. At the end, a conclusion has summarized all the ideas discussed in this report. As expected this project should be able to display the tomographic mapping through the color pattern which able to interpret the ECG according to the medical prediction with the greatest accuracy.

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# **CHAPTER 1**

## **INTRODUCTION**

A general overview of ECG signal is introduced in this chapter. This chapter discussed about the possible problems facing when interpreting and analyzing the ECG signal. And lastly, the project objectives and scopes discussed within this chapter.

### **1.1 Background of Study**

Heart is a very important part in human lives. Due to this fact, many people nowadays have been aware about the heart disease attentively. That is the reason why people tend to spend a lot of money by consulting doctor, if in case any possible heart disease symptom happened. Since a long ago the scientists has already thought and generate idea to overcome this problem. Then, they come out with the ECG machine to enable for easily check and diagnose the heart related disease. Basically the electrocardiogram (ECG) is the machine invented to diagnose the heart disease matter. ECG analysis is a routine part of any complete medical evaluation, due to the heart's essential role in human health and disease, and the relative ease of recording and analyzing the ECG in noninvasive manner. Instead of that, the development of this machine is also capable to display the heart pulse in a specific waveform. The interpretation of this waveform by the medical doctor enables to monitoring the functioning of heart and relates it to the disease symptoms of the patient.

### 1.1.1 *Electrocardiogram Signals*

The electrocardiogram (ECG) is well known, recognized and commonly used in medical field. The Electrocardiogram is the machine invented to record the electrical activity of the heart and it normally can be recorded through *electrodes* attach on the limb or chest. However the ECG signal are tend to have the spontaneous discharge due to a broad number of factors affect the ECG, including abnormalities of cardiac conducting fibers, metabolic abnormalities (including a lack of oxygen or *ischemia*) of myocardium, and macroscopic abnormalities of the normal geometry of the heart [7]. Be aware that the ECG is liable to have misinterpretation. It can indicate that the patient is having the abnormalities when the heart is perfectly health. It also can suggest the medical expertises that the heart is completely normal when in fact it have the severe myocardial infarction.

The medical professionals are capable to diagnose the heart related disease based on the waveform obtained. They interpret it through their knowledge and lesson learned from the experience they got from the medical field. Most of the ECG were invented to deliver the information in term of the waveform signal. The interpretation of the functioning of heart represented by the waveform might not be 100% true. Some error might be happened during the interpretation process caused by the scale of waveform or the vibration of this waveform.

ECG signal only able to represent the information in waveform type. Based on the theory learned by the medical doctor, they still facing the problem to diagnose the heart disease from the waveform signal. Due to this fact the medical doctor has proposed to have the better way to interpret the ECG. Several solutions have been discussed to improve the understanding of ECG. Modeling the cardiac signal as the tomographic map has been one of the proposed method to overcome this problem. The ECG waveform will be transformed into 3 main color representation; Red, Blue and Green for a better understanding.

### 1.1.2 Standard ECGs Features

Clinical assessment on the ECG signal normally interested in measurement of intra beat timing and amplitudes. Averaging over the beats is the normal way to reduce the noise presence in the signal. The complex changes in ECG morphology have become the sign of the problem existence. The clinical able to obtain the good assessment of the cardiac abnormalities based on just a few measurements [2]. Table 1.1 shows the features of the ECGs for normal human heart.

Table 1: Typical Lead II ECG Features and Their Normal Values in Sinus Rhythm at a Heart Rate of 60 bpm for healthy Male Adult [2].

Feature	Normal Value	Normal Limit
P width	110 ms	$\pm 20$ ms
PQ/PR interval	160 ms	$\pm 40$ ms
QRS width	100 ms	$\pm 20$ ms
QTc interval	400 ms	$\pm 40$ ms
P amplitude	0.15 mV	$\pm 0.05$ mV
QRS height	1.5 mV	$\pm 0.5$ mV
ST level	0 mV	$\pm 0.1$ mV
T amplitude	0.3 mV	$\pm 0.2$ mV

There are some variations between the lead configurations. There are a few factors that change the values such as heart rate, respiration patters, gender, disease and drugs. For normal healthy adult, 95% of them have QTc between 360 ms to 440 ms. But for female adult, they tend to have 3% to 6% longer than males. The intervals also elongate with age, approximately 10% per decade.

## **1.2 Problem Statement**

From the study, the biomedical signals has proven the significance to analyze physiological events in order to diagnose the health condition of the human. Analysis the biomedical signals requires the identification and deeper investigation of the corresponding events. Once an event has been successfully identified, and it should be analyzed in terms of a few important parameters.

For the purpose in getting the accurate method in analyzing the ECG, several methods has been proposed by the scientist. But none of these method has been implemented as the specific method. Today, the medical officer interpret the ECG signal manually base on the basic of knowledge learn from the medical field. Interpretation of the patient heart condition through the ECG signal obtained is seemed to be difficult. This project integrates the knowledge of medical and electronic field to design the ECG analyzer which gives user better way in translating the signal accurately to the disease definition.

## **1.3 Project Objectives**

The aim for this project is basically to learn and gain knowledge regarding the ECG signals and its interpretation. The objectives are:

- To understand the main primary concept of ECG and the important principle to interpret the ECGs.
- To preprocess the ECG signal before it can be converted to tomography mapping.
- To create an algorithm for interpreting ECGs and tomography mapping transformation.
- To display the ECGs interpretation using the RGB scaled mapping.
- To develop a simulation model for analyzing the ECGs based on the coding defined.

## **1.4 Project Scopes**

- **Self study on the fundamental feature of ECG signal.**  
To proceed with this project, the student required to study the physiological basis of the Electrocardiogram. Besides that, in addition, manual translation of the ECG signal should be understood. The student also must be able to conclude the patient condition according to the ECG waveform given.
- **Understanding the MATLAB components.**  
MATLAB is the main software used in this project. Therefore, the student is required to be specialized in MATLAB programming. GUI is the toolkit in MATLAB used to design the user interface.
- **Algorithm of transforming the ECG waveform to tomographic mapping.**  
For this scope, the student required to some reading from the previous research papers. The purpose is to collect more information regarding the method to be used. For this project, the student needed to enhance the previous project from 2D grayscale representation to RGB scale representation. The intensity of the color pixel shows the severity of the heart condition.
- **Implementing the algorithm using MATLAB.**  
After selecting the appropriate algorithms, the implementation stage starts using MATLAB. The output of this code must be able to display RGB scale (tomographic mapping) as the meaning of ECG interpretation.
- **Project Testing on difference kinds of ECG Signal.**  
After the implementation stage, the student should test the project performance using different kinds of ECGs. The system also must able to be tested on the some patients who are suffering of various heart diseases such as angina, sudden cardiac arrest and etc. The output of the testing should be parallel with the manual interpretation of the medical doctor.



- **Designing the Graphic User Interface for modeling the project.**

**After completing the most suitable algorithm, the modeling part must begin. At first, the algorithm should be written to MATLAB programming before integrating into designed interface. The student must be able to integrate the transformation algorithm to the Graphic User Interface (GUI).**

## **CHAPTER 2**

### **LITERATURE REVIEW**

Before proceeding to the implementation stage of the ECG interpretation using the tomography mapping, some theoretical knowledge should be learned and well understood. In this chapter the reader is introduced to the glance knowledge on how the heart is functioning and the characteristics of ECGs.

#### **2.1 Heart**

Heart is the main part in human body. Heart is the pear shaped, responsible for pumping blood through the blood vessel deliver the oxygen and nutrient demands of the body tissue as well as removing the carbon dioxide. The heart is composed of cardiac muscle, an involuntary muscle tissue which found only within muscle. There are for chamber in heart which is right atrium and right ventricle, the left atrium and left ventricle [6]. The right atrium collects impure blood from the superior and inferior vena cavae. Starting in the right atrium, the blood flows through the tricuspid valve to the right ventricle during atrial contraction. The impure blood in the right ventricle is pumped out during ventricular systole through the pulmonary valve to the lungs for purification. During the atrial contraction, the left atrium receives purified blood from the lungs, which is passed to the left ventricle via mitral valve. The most important cardiac chamber is the left ventricle which is the largest cardiac chamber and contract strongest between the cardiac chambers, as it has to pump out the oxygenated blood through the aortic valve and the aorta against the pressure of the rest of the vascular system of the body [6].

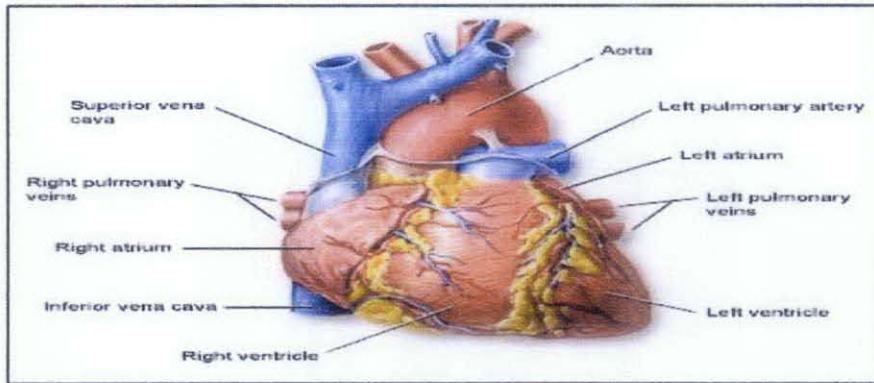


Figure 1: The heart

(source by American Accreditation HealthCare Commission, Medline, 2009)

## 2.2 Electrocardiogram (ECG) Signals.

As mentioned previously, ECGs is the core part of this project. Electrocardiograph is an important signal gained from the human heart muscle activities. Electrocardiograms are the signal representing the cyclical contractions and relaxation of human heart muscles. The electrical signal of heart is recorded from the combination of electrodes placed at specific points on human body [4]. When interpreting the ECG signal, normally medical officer give attention on the S wave, PR interval, QRS complex, ST segment and T wave. From figure 2.2, ECGs is the combination of several components such as:

- P wave: the sequential activation (depolarization) of the right and the left atria.
- QRS complex: right and left ventricular depolarization.
- ST-T wave: ventricular depolarization.
- U wave: represents 'after depolarization' in the ventricles.
- PR Interval : time onset from onset of atrial depolarization to onset of ventricular depolarization
- QRS duration: duration of ventricular muscle depolarization
- QT interval : duration of ventricular depolarization and repolarization
- RR interval: duration of ventricular cardiac cycle.
- PP interval: duration of atrial cycle

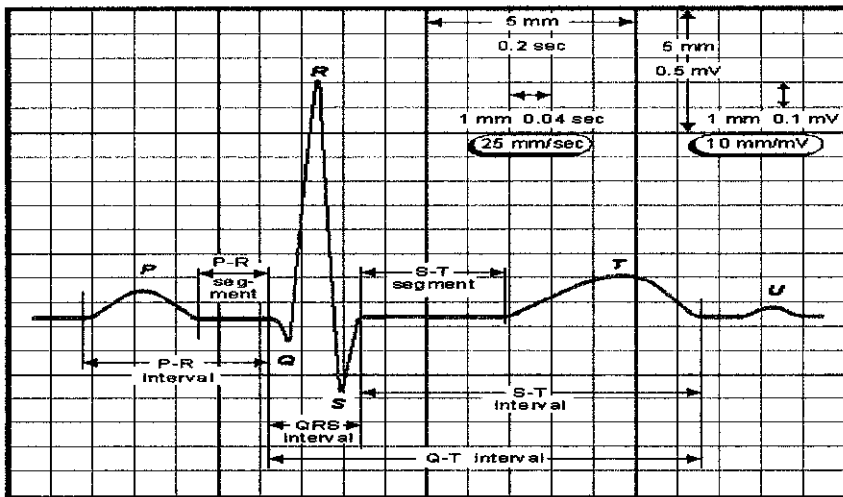


Figure 2: Idealized pattern of one cardiac cycle

(source by JON Barron, Secret of the Heart Newsletter, 2007)

### 2.3 ECG Comparison Properties

Normally heart muscle not directly controlled by brain. There are a set of pace making cells to generate the electrical pulse synchronization. Some electrical pathways will be block to the heart muscle if the patient had the heart disease. This action is due to the disturbing rhythm of the electrical pulses [8]. There are several properties being used to compare the ECGs signal with the standard ECG.

- Time interval of each wave and interval between similar waves of adjacent cycles.
- Amplitude between the waves.
- Location and magnitude of additional waves known as bumps.
- Duration between waves/bumps.
- Rate of rise/fall of the waves/bumps.
- Position of bumps/ waves compared to the signal DC level.

As developed from time to time, ECG has become the necessary tool to analyze tool to analyze human heart condition. Improvement in digital signal processing has increased the features values in ECG signal. As the consequent, electrocardiograph has become the essential modern medical instrumentations.

## 2.4 Detection and ECG Extraction

Extraction of various features is important for ECG classification. ECG are extracted from the QRS complex and ST segment to illustrate the periodic properties [3].

- *QRS complex*: This characteristic brings a lot of information in order to trace heart abnormalities. For normal heart, it should be varied from 0.04 to 0.09 second. The PR interval gives the significant of the start of atrial depolarization to the start of ventricular depolarization and allows atrial systole to occur.
- *ST segment*: Two important features can be obtained from this segment; level and slope of the ST segment. The level is determined by the deviation of the isoelectric level. The isoelectric is defined between the offset of P wave and the onset Q-wave. While for the slope, it is determined by difference between the amplitude of the starting point of the starting point and end point.

New concept of time series averaging;

- *Expectation Vector*: One of the most important parameters in statistical modeling is expectation vector or mean of the random vector. Expectation value is defined as the mean of a time series with n data.

$$E[x(n)] = M = \frac{1}{N} \sum_{n=0}^{N-1} x_n \quad (1)$$

- *Covariance Matrix*: Another important parameter is covariance matrix which indicates as the dispersion of the distribution. Power spectrum of the signal can be applied to the classification of cardiac arrhythmia problem. The operation of convolution in time domain similar to the correlation and more specifically the calculation of cross covariance and hence, autocorrelation function and the power density spectrum are Fourier transforms of each other. The classification of ECG can be obtained by simply identifying the highest correlation between a set of ECG signal.

## 2.5 Average Window Mean

Average window mean is the calculation of the mean value within the selected window size. Mean is defined by;

$$x_i = \frac{1}{N} \sum_{n=1}^N x_n \quad (2)$$

Where N is the size of the window,  $x_n$  is the value of the signal of each sample.

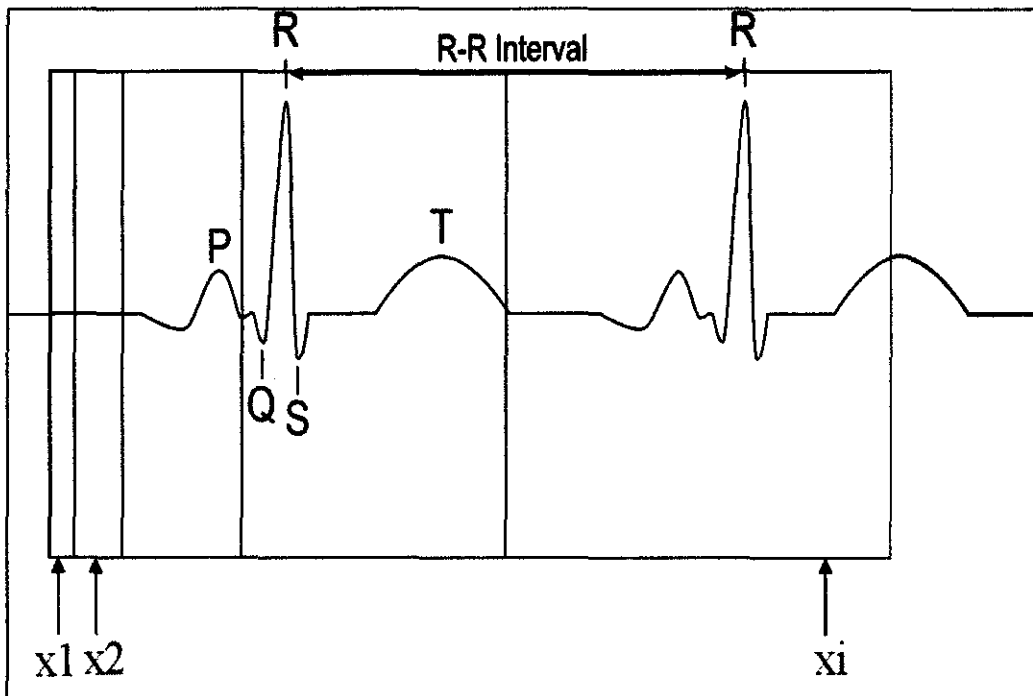


Figure 3: Average Window mean

The value of mean should be determined with respect to window size used. The mean value should be in  $1 \times i$  matrix form.

$$X = \begin{bmatrix} x1 \\ x2 \\ x3 \\ \vdots \\ xi \end{bmatrix} \quad H = X.X^T = \begin{bmatrix} x11 & x12 & - & - & x1i \\ x21 & x22 & - & - & x2i \\ - & - & - & - & - \\ - & - & - & - & - \\ xi1 & xi2 & - & - & xii \end{bmatrix}$$

## **2.6 ECG interpretation**

ECG used by the doctors to diagnose and determine the heart abnormalities. The impulses of heart is being displayed on the monitor and then printed on the graph. The ECGs is interpreted by reading the graphed ECG signal.

Normally, procedure used to get the idea of the heart function is by comparing current analyze ECG with the standard / normal ECG. Abnormalities present in term of heart rate, heart rhythm or contractions and relaxations. Most of the ECG interpretation is begun by searching the recurring patterns. So, firstly the technicians will look at the patient heart rate. Electrodes are used to stimulate the heart into contracting then relaxing. P spike represents the impulses from the upper chamber of the heart. The PR interval represents a bridge between contracting and relaxing of the atria.

The results of ECG may become the basic of the additional treatment. Due to this main reason, the highly trained ECG technicians have been given first authority to interpret the ECG results.

## 2.7 Tomographic Mapping and ECG

Tomographic mapping is a method to represent the ECG into 3 dimensional color patterns known as RGB scale which stands for Red, Green and Blue. In RGB color model, a color is represented by indicating how much each ingredients of red, green, and blue should be included in it. Each can differ from the minimum (no color) to the maximum (full intensity). When all the colors are at the minimum value, then the displayed color will be black. And when all the colors are at their maximum value then the displayed color will be white. People are tend to to be sensitive to this primary colors and in fact other colors as well precieved as the combination of this 3 main primary color. Since this project use this approach to interpret the ECG waveform, it should be easier for the ECG technician to diagnose the heart related problems referring to the pattern of colour cluster.

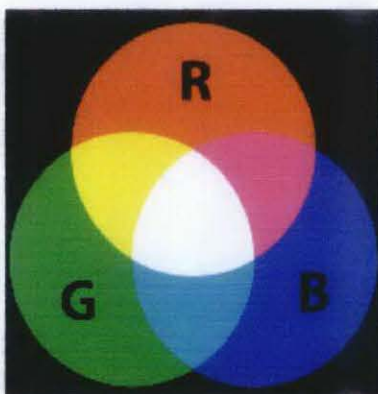


Figure 4: The RGB



## **CHAPTER 3**

### **METHODOLOGY/PROJECT WORK FLOW**

This chapter explains about the methodologies used to implement in this project. It is begin with defining the project goal and the engineering tools used. This chapter also includes the details of the methods used in this project.

#### **3.1 Project Adaptation**

This project starts with the establishment of the proper objectives and scope which are understandable and realizable. The main project scope is to study the fundamental concept of the ECG signals, basic interpretation of the ECG signal, and the basic ECG feature extraction. While for the project background, it is studied and being review on the literature chapter for discovering the possible solutions. The basic concept for ECG interpretation is the crucial part to be clearly understands. After this well establish concept truly understand, a suitable tool has been chosen for the project implementation. This project use the MATLAB programming and the Graphic User Interface (GUI) component for the tools. MATLAB provide a good solution enabling engineers to reduce the time to solve, to develop the system computing and many other systems. Integrating the MATLAB coding with the GUI components, enable the system to display the suitable output.

Once objectives for the project defined, the suitable project flow is designed. The figure 3.1 shows the project flow.

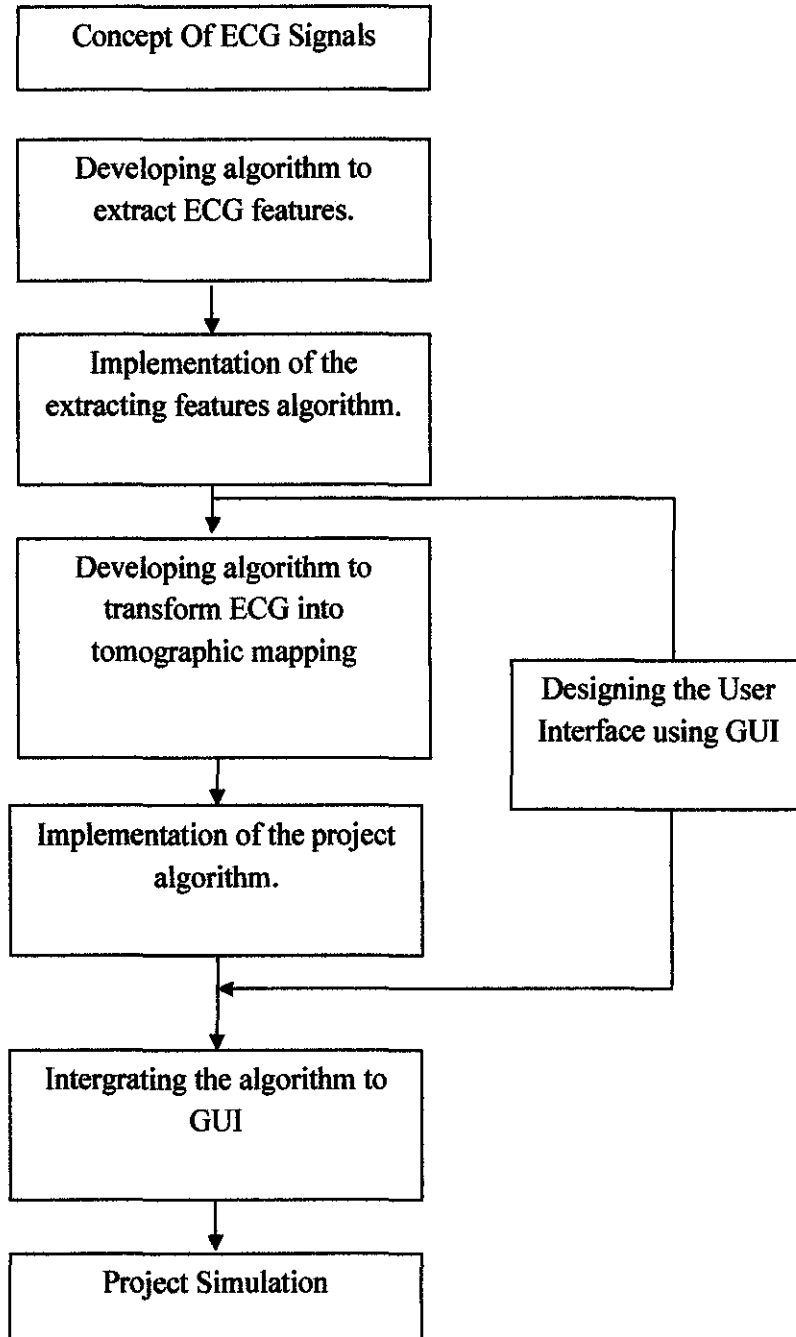


Figure 5: The project flow

### **3.2 Basic Concept of ECG Signal**

As mentioned previously, ECG is the main part for this project. The concept of ECG interpretation must be clearly understood in order to lead into a good project implementation and accurate ECG translation.

Heart is the most important organ for our body which acquires intensive care in term of medical need. The heart is comprised of muscle (myocardium) that is rhythmically driven to contract and hence drive the circulation of blood throughout the body. Before every normal heartbeat, a wave of electrical current will passes through the entire heart. This wave will trigger the myocardial contraction. The electrical propagation pattern is not random, but spreads over the structure of the heart in coordinated pattern which leads to an effective coordinated normal heartbeat. This results in a measurable change in potential difference on the subject's body surface. The resultant amplified and the signal is known as an electrocardiogram [7]. This project requires the student to be able to manually interpret the ECG signal. This part includes the way how the student interprets the S wave, PR Interval, QRS Complex, ST Segment, and T wave. Each segments effect should be understand clearly. This will help in developing the algorithm for signal transformation.

Processing the ECG in time and frequency domains has been used in medical diagnosis by monitoring and graphically tracing the electrical activity of the heart. The analysis of ECG waveform is often measuring the period of ECG waveform signal and comparing it with the normal waveform signal.

The ECG signal interpretation still liable to have misinterpretation. This has been the serious issue raised by the scientist and medical doctor. Due to this misinterpretation, it may cause the serious effect on the patient. However this project comes up with idea to design a simulation system that able to interpret the cardiac signal. The solution is to interpret the ECG waveform using the tomographic mapping.

### 3.3 Graphic User Interface

For every system, user interface plays an important role. The interface is design in such a way that is friendly to the user and a lot of information can be displayed. This task requires a lot of information regarding the GUI component in order to build a good interface.

### 3.4 Developing algorithm for ECG features extraction

This part plays as the core part for this project implementation. Several algorithms have been studied to establish a better idea for the ECG interpretation. Transforming the ECGs into the tomographic mapping is better for interpretation approach. In this study, the way how the ECG being transformed is obtained by calculating the variation of the signal fluctuation for every each time sample. Then the mean value for each window sizes and the matrix multiplication for each value calculated. The mean value is the important parameter because it is representing the signal fluctuation over the average value of the signal. The formula for the mean value is given by the equation (1);

$$E[x(n)] = M = \frac{1}{N} \sum_{n=0}^{N-1} x_n \quad (1)$$

Where E is the expectation value and N as the number of data points.

### 3.5 Implementation of the extraction algorithm with MATLAB

After choosing the best algorithm for the ECG interpretation, the implementation is begun using the MATLAB. Before proceeding with the RGB scale, the ECG has been divided into 4 stages.

*Step 1: Calculate the Difference ECGs.*

The changing in amplitude allows us to check the signal properties. Thus from this step, the variation of the signal amplitude in time domain can be calculated. Difference ECGs is the sum of the ECG different while Absolute Difference ECGs provide all the positive value of the difference by placing the absolute sign.

*Step2: Calculate the signal Mean*

The signals mean representing how the signal is fluctuated over the time. This implementation provide us the calculation to obtain the ECG signal mean (Mecg), the mean of ECG Difference (MD) and lastly the Absolute Difference (MAD). To obtain these three important values, this project using the Average Window Mean approaches. There are 9 sizes of windows used to obtain the mean values. These values give the clearer information regarding the analyzed ECG. Mean values are calculated using this equation;

$$x_i = \frac{1}{N} \sum_{n=1}^N x_n \quad (2)$$

Where N is the size of the window,  $x_n$  is the value of the signal of each sample.

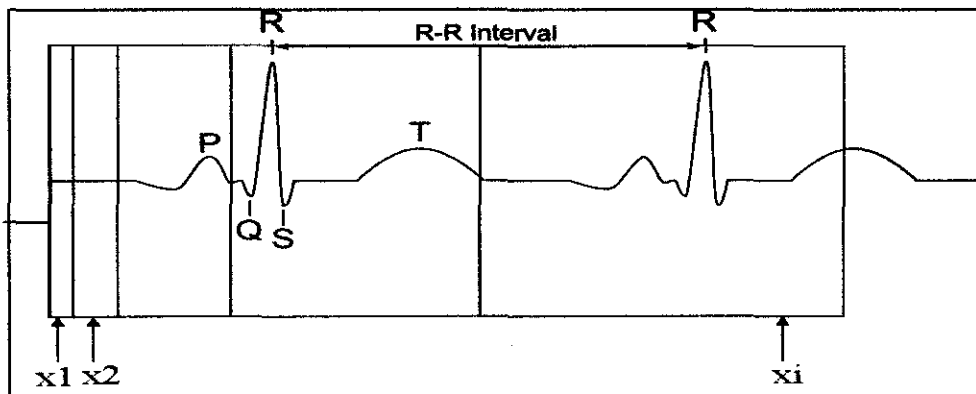


Figure 3: Average Window mean

### *Step 3: Performing the 2D grayscale images. [1]*

After calculating the mean values, the conversion is begun. Previously, 9 windows have been used. This step will allow us to create 9x9 matrixes. This allows us to have 9x9 mapping grayscale. The image represents the meaning of ECGs over the time. The black color display means the patient is in critical condition, higher ECG variation. White display means the patient has no ECG pulses and grey display means the patient is in normal condition.

### *Step 4: Performing the RGB scale images (tomographic mapping)*

From the 2D grayscale, the interpretation of the ECG signal is being enhanced by the 3D RGB scaled. For Mean Ecg data, this will transform the matrixes into Blue scale mapping and Green scale for Mean Difference and lastly Red for Mean Absolute Difference. The color representation is coming with meaning attached.

## **3.6 Tools**

This project is more focused on the simulation. Therefore no tool/equipment/hardware are required towards designing this system. However, this project requires a complete package of MATLAB and GUI Components. Computer is assigned to be the device required to run the simulation.

## **CHAPTER 4**

### **RESULTS AND DISCUSSIONS**

This chapter shows the current project implementation and simulation conducted. For this time being, the student has built the algorithm used to extract the ECG features. This algorithm is the important step in performing the signal analysis.

#### **4.1 MATLAB Coding for analyzing ECGs Signal**

Before proceed to the RGB scale, the student have to analyze the ECG signal. Based on the signal the student is interested in finding the vertical and horizontal surge in amplitude. In order to be able to transform the ECG signal into RGB scaled, a few algorithm must be designed to interpret the signal. As I mentioned in the chapter 3, basically there are 3 steps taken to perform this task. Figure 4.1 shows the details of steps taken.

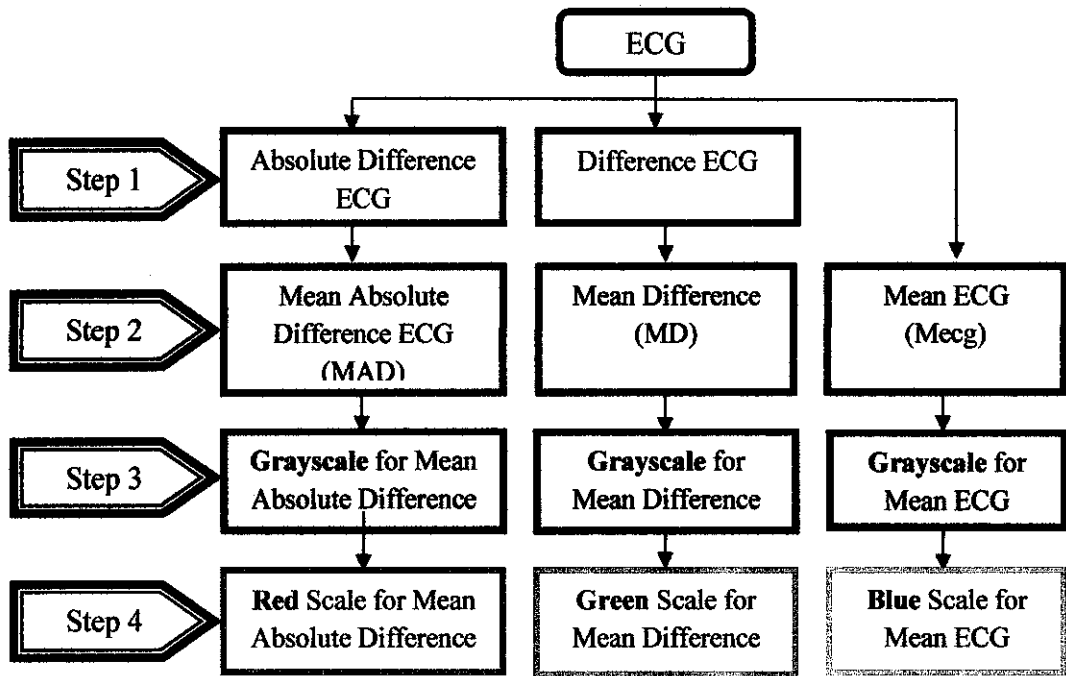


Figure 6: Algorithm to analyze ECG signal

From the figure 4.1 the project starts with calculating the Difference and Absolute Difference in ECG. Then the second step, computes the mean Difference ECG (MD), the mean of Absolute Difference (MAD) and lastly the ECG (Mecg). From these values, the ECG is transformed into **grayscale** [1]. Then from grayscale, the data representation being transform into **Red**, **Green** and **Blue** respectively with meaning attached for a better understanding.



## 4.2 Difference and Absolute Difference of ECG

These values are calculated to check the variation of the ECGs for every second of signal. From this operation, the ECGs features are being extracted. The MATLAB coding used to calculate the Difference and Absolute Difference of ECG is attached to the Appendix A.

From, the coding, the graph in figure 7 shows the ECG Signal, Difference and the Absolute Difference of ECG.

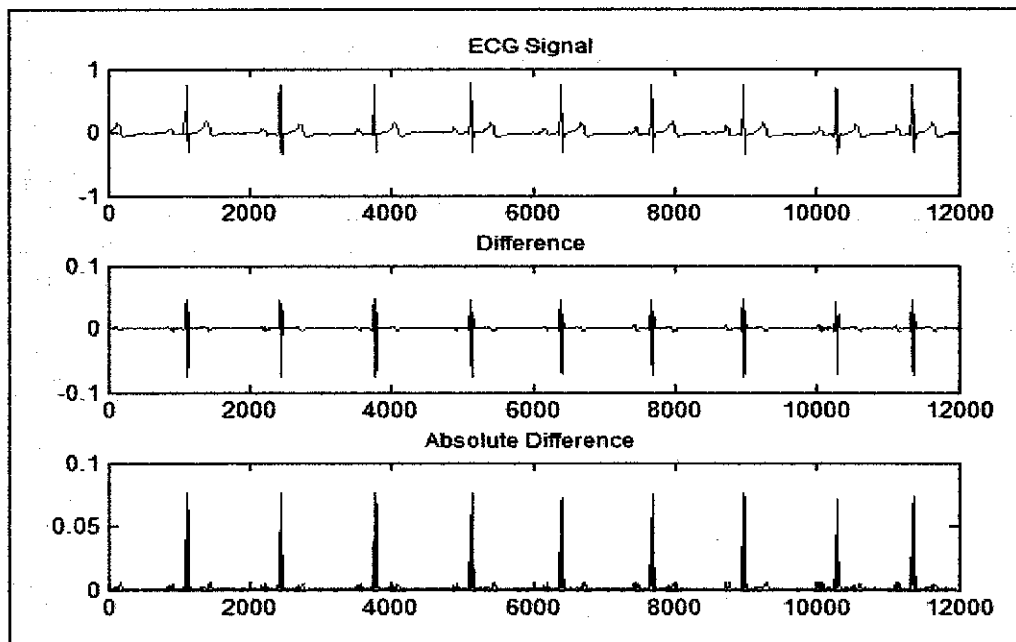


Figure 7: ECG Signal, Difference and Absolute Difference

This figure consists of 3 graphs, the ECG signal, Difference ECG and the Absolute Difference of ECG. From the ECG signal, we can define manually the important segments such as PR Interval, QRS Interval, ST Segment and T Wave. The variation in ECG amplitude leads to observe the Difference in ECGs. When the variation of signal is large for example during R Wave the Difference value is maximum The Absolute Difference obtained by applying the absolute sign to Difference ECG. This value shows the positive amplitude of Difference ECG.

### 4.3 Mean ECG

Mean value is the summation of the signal for every sample divided by the number of sample. The purpose of this calculation is to observe the signal fluctuation. This MATLAB coding shows how to calculate the mean of ECG signal using window size 8.

```
winMecg8 = [];  
for k= 1:r-8  
    meanECG8 = mean(ECG(k:k+7));  
    winMecg8 = [winMecg8; meanECG8];  
end  
plot(winMecg8);
```

For the mean value of ECG, there are 9 windows have been used to calculate these values. The reason why it has various sizes of windows is to check the variation of the mean values. The sizes are, 2, 4, 8,16,32,64,128,256 and 512. Figure 8 shows the mean ECG for window size 8.

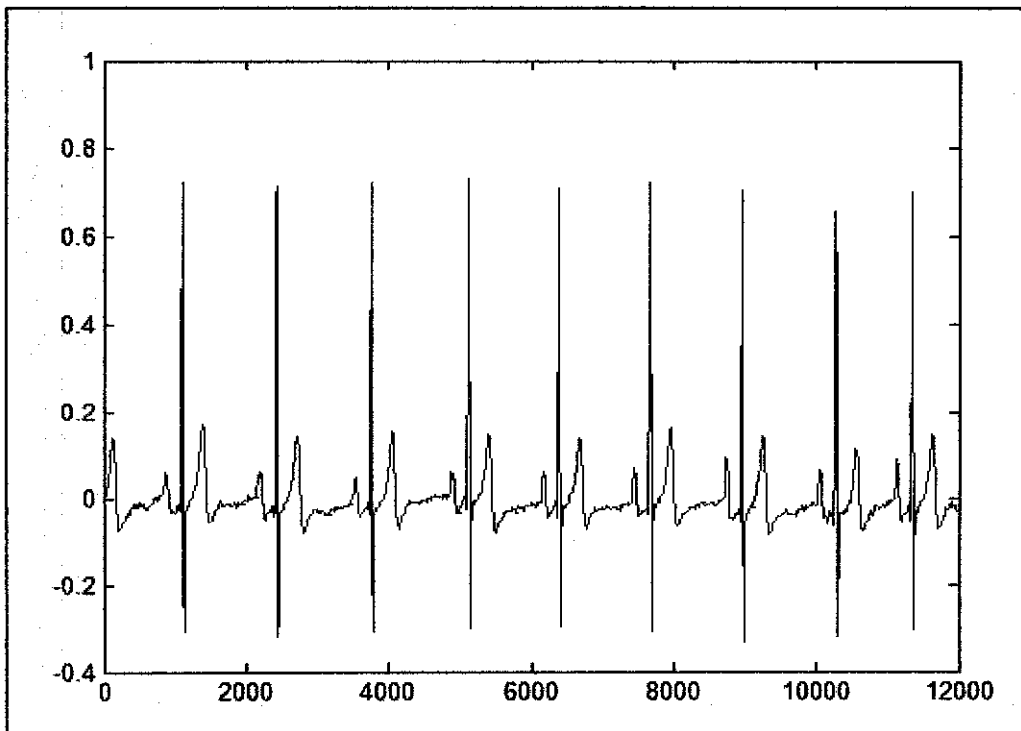


Figure 8: The Graph for Mean ECGs for window size 8

#### 4.4 Mean Difference

This calculation is performed after finish calculating the Difference of ECG. It allows us to see the fluctuation of the Difference ECG. This coding is used to calculate the mean Difference of ECG for window size 8.

```
winMDiff8 = [];  
for k = 1:r-8  
    meanDiff8 = mean(Diff(k:k+7));  
    winMDiff8 = [winMDiff8; meanDiff8];  
end  
plot(winMDiff8);
```

As previously, this calculation also being applied to the 9 window sizes. The detail of the signal variation is observed. As for the figure 9 it shows the mean Difference for window size 8. As we can see, the value is range between -0.08 to 0.04.

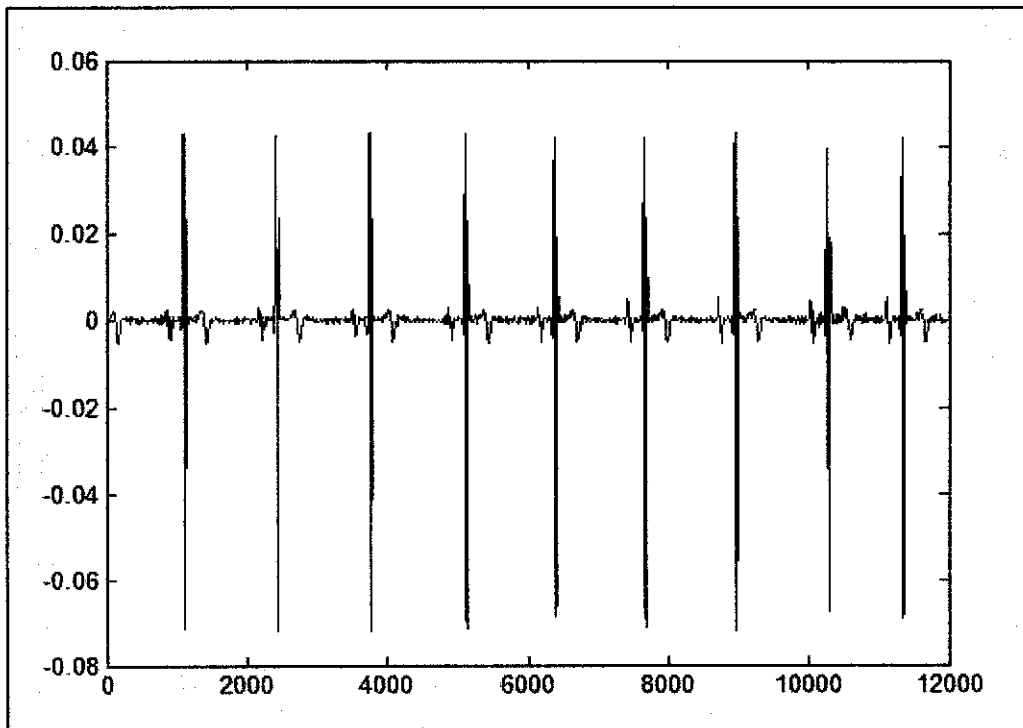


Figure 9: Graph for Mean Difference ECGs for window size 8

#### 4.5 Mean Absolute Difference

Another important part is calculating the mean for Absolute Difference of ECG. As before, this calculation is performed after the absolute Difference of ECG being computed. The sample coding for window size =8 is shown below;

```
winMADiff8 = [];  
for k = 1:r-8  
    meanADiff8 = mean(ADiff(k:k+7));  
    winMADiff8 = [winMADiff8; meanADiff8];  
end  
nlot(winMADiff8);
```

Figure 10 shows the mean Absolute Difference values for window size 8. As we can see the amplitude range for this size of window is from 0 to 0.08.

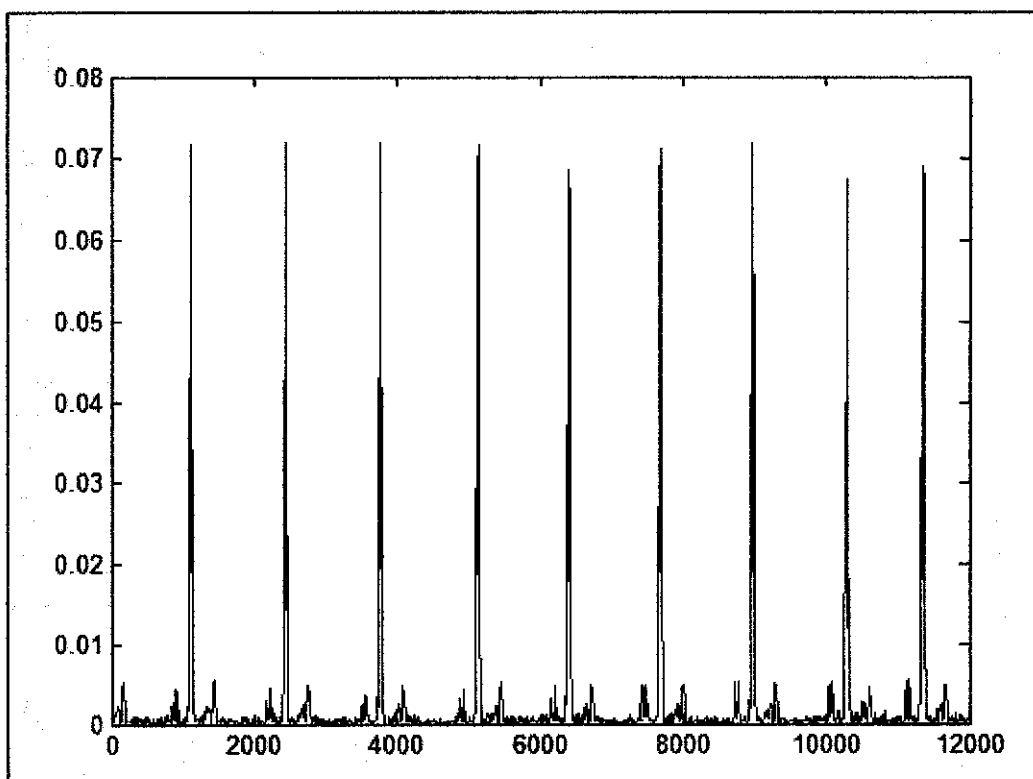


Figure 10: Graph for Mean Absolute Difference ECGs for window size 8

#### 4.6 2D Grayscale Display [1]

In this project, 9 average window sizes are used to observe the characteristics of the ECGs. Mean of each window is calculated using equation (1). By arranging those value in 1x9 matrix form. The following matrix is obtained;

$$X = \begin{bmatrix} x1 \\ x2 \\ x3 \\ \vdots \\ xi \end{bmatrix} \rightarrow H = X.X^T = \begin{bmatrix} x11 & x12 & - & - & x1i \\ x21 & x22 & - & - & x2i \\ - & - & - & - & - \\ - & - & - & - & - \\ xi1 & xi2 & - & - & xii \end{bmatrix}$$

There set of matrices namely; Mecg, MD and MAD obtained from the previous step. The elements of 9x9 matrix are being normalized by dividing each element by the maximum value of element. The normalized values used as the color index to transform the signal into grayscale representation. The color index should be varying from 0 to 255. 0 represent black while 255 represent white. The index value within this range will vary the intensity of the gray color.

The color intensity represents the condition of patient heart. The black indicated that the patient is in stress condition while white will have no pulse at all. While the gray displays the patient is in healthy condition. The display manipulation of grayscale is obtained using difference expression for each data; Mecg, MD and MAD. The expression is shown as below;

$$\text{Mean of ECG : } \text{ceil}(125-125*\text{clrIDZ}) \quad (3)$$

$$\text{Mean Difference of ECG : } \text{ceil}(125-125*\text{clrIDY}) \quad (4)$$

$$\text{Mean Absolute Difference of ECG : } \text{ceil}(255-255*\text{clrIDX}) \quad (5)$$

Ceil function is used to get the integer value to manipulate the grayscale intensity. The color index is obtained by manipulating the 3 signals; Mecg, MD and MAD. The sample of MATLAB code to display the grayscale representation is attached to Appendix A.

#### **4.7 3D RGB Scale Display**

For a better approach of understanding the ECG signals, there are some modifications on the way how the data is being represented. With 100 data in one second, it is nice to see the pattern of behavior in one or two seconds. Even the medical professionals cannot interpret the reading, but within a colored pattern with some meaning, it should be interesting. This part will transform the ECG signal into the color representation. The intensity of the color will indicate the severity of the heart condition.

Some modification should be made in MATLAB programming to enable the color representation of the ECG signal. These are the changes made to enable the color display instead of grayscale. The sample algorithm to perform this transformation can be obtained from Appendix A.

#### **4.8 Input Data Analysis**

Three 8 different types of ECGs have been used to represent the normal ECG and the other three different types of ECGs representing heart disease namely Atrial Fibrillation, Ventricular Fibrillation and Sudden Cardiac Death.

##### *4.8.1 Normal Sinus Rhythm*

Normal sinus rhythm is defined as normal regular heart rate set by the heart pacemaker. The pacemaker is located in the wall of the right atrium. The sinus node generates an electrical impulse which travels through the right and left atrial muscles producing electrical changes which is represented on the electrocardiogram (ECG) by the p-wave. The electrical impulse then continues to travel through specialized tissue known as the atrio ventricular node, which conducts electricity at a slower pace. This will create a pause (PR interval) before the ventricles are stimulated. This pause is helpful since it allows blood to be emptied into the ventricles from the atria prior to ventricular contraction to propel blood out into the body. The ventricular contraction is represented electrically on the ECG by the QRS complex of waves. This is followed by the T-wave which represents the electrical changes in the ventricles as they are relaxing. [7]

For the normal sinus rhythm, the student used two types of data for testing purpose. Figure 11 shows the sample 1 Normal Sinus Rhythm ECG data displayed in grayscale. Figure 12 shows all the data transforms into RGB display. While figure 13 and figure 14 show the data interpretation for the second data sample of Normal Sinus Rhythm. As we can observe, the normal ECGs have greenish pattern while being simulated.

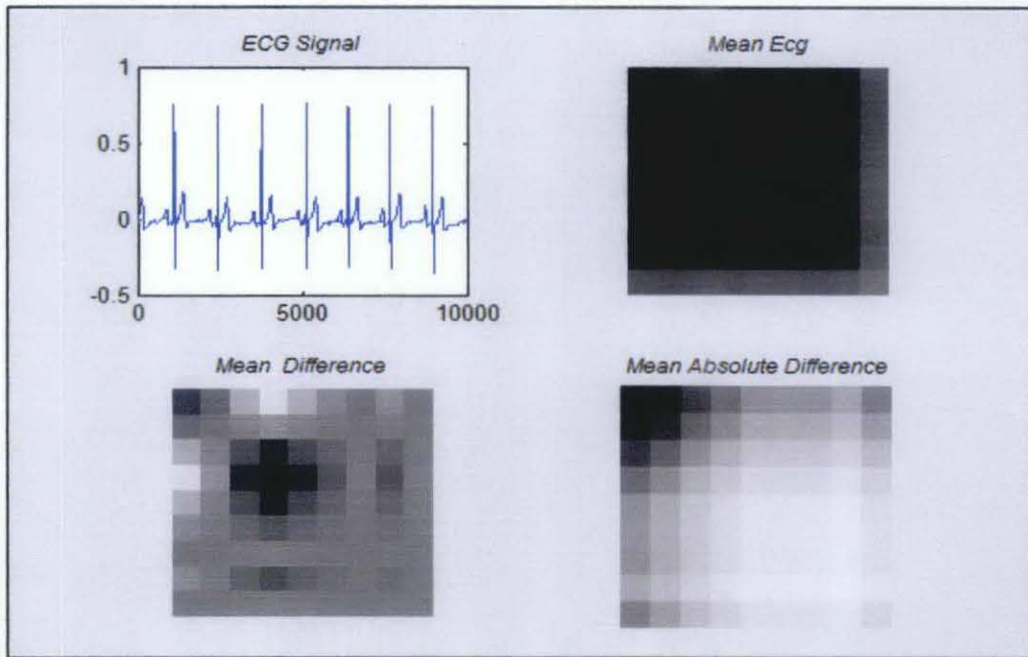


Figure 11: *Grayscale* Normal Sinus Rhythm Data #1

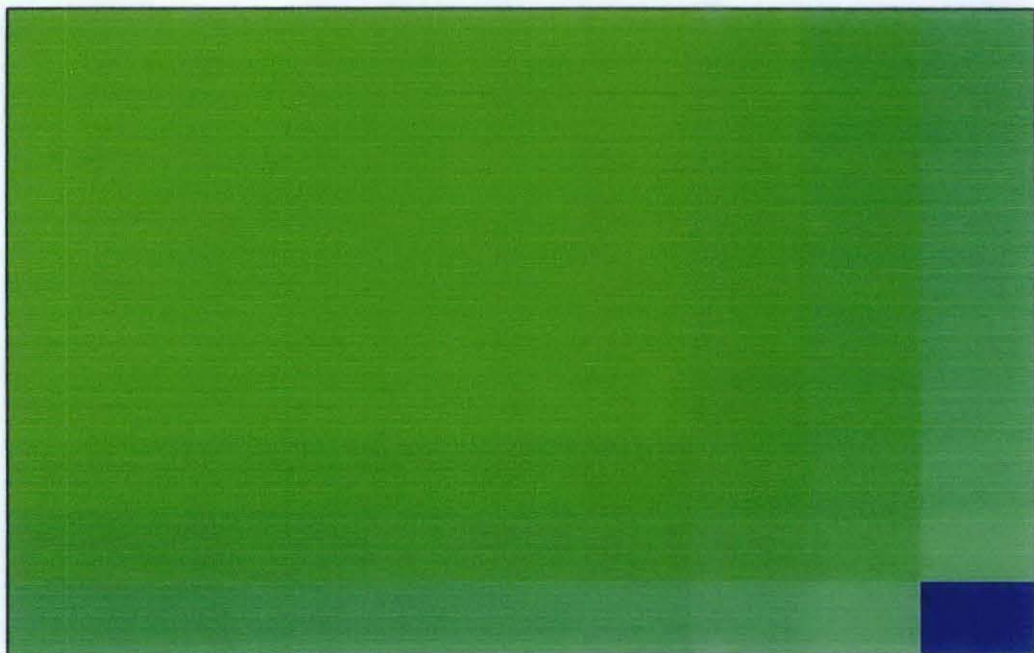


Figure 12: *RGB scale* Normal Sinus Rhythm Data #1

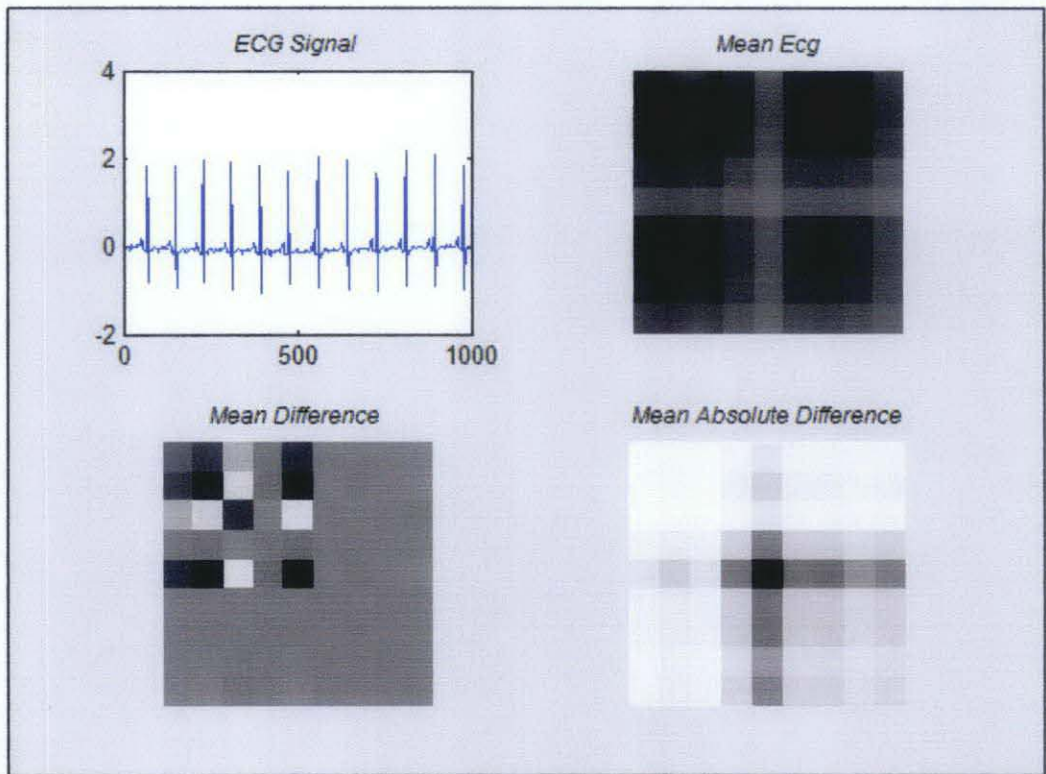


Figure 13: *Grayscale* Normal Sinus Rhythm Data #2

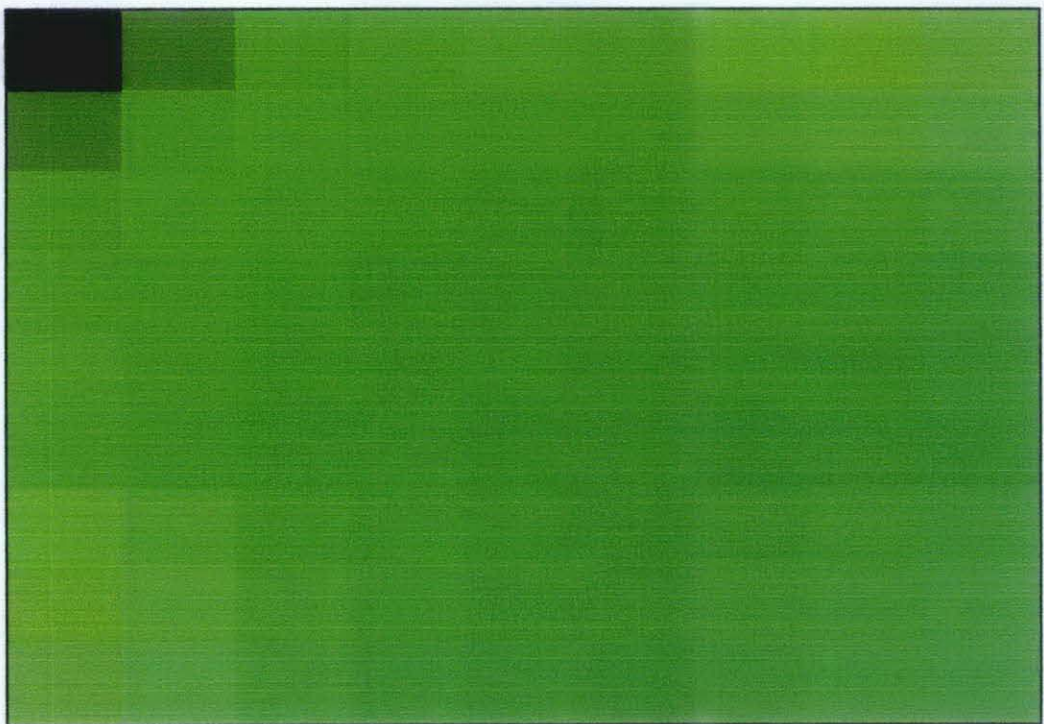


Figure 14: *RGB scale* Normal Sinus Rhythm Data #2



#### 4.8.2 *Ventricular Fibrillation*

Ventricular fibrillation is the mostly commonly identified arrhythmia in cardiac arrest patients. This arrhythmia is a severe derangement of the heartbeat that usually ends in death within minutes unless corrective measures are promptly taken. This condition is very dangerous. It is dangerous because it may degenerate further into a totally disorganized electrical activity. Ventricular fibrillation disrupts the synchrony between the heartbeat and the pulse beat. In ventricular fibrillation, heart action is so disorganized that it quivers and does not contract, thus failing to pump blood.

The most common cause of ventricular fibrillation is inadequate blood flow to the heart muscle due to coronary disease. The other causes are; very low blood pressure, the electrical shock, drowning and including drug that affects electrical currents in heart. [8]

Figure 15 and 16 show both Malignant Ventricular Fibrillation ECG data, Mecg, MD and MAD displayed in grayscale. While, figure 17 and 18 show all the data interpreted in RGB color display. As we can observe, the abnormal ECGs will show the reddish pattern at the output display.

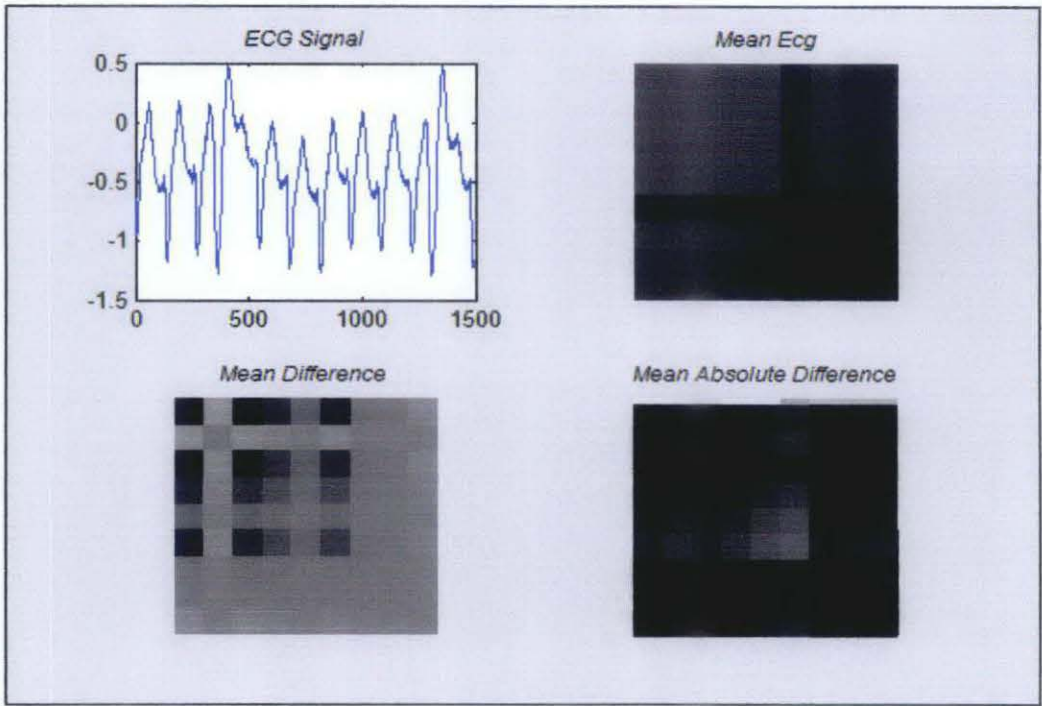


Figure 15: *Grayscale* Ventricular Fibrillation Data #1

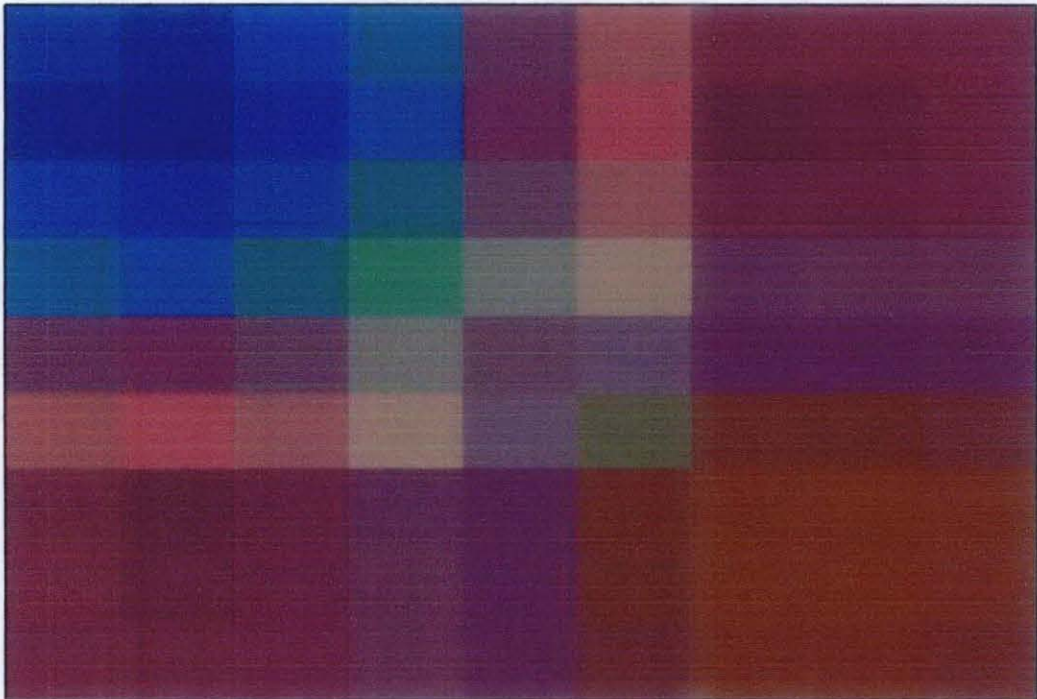


Figure 16: *RGB Scale* Ventricular Fibrillation Data #1

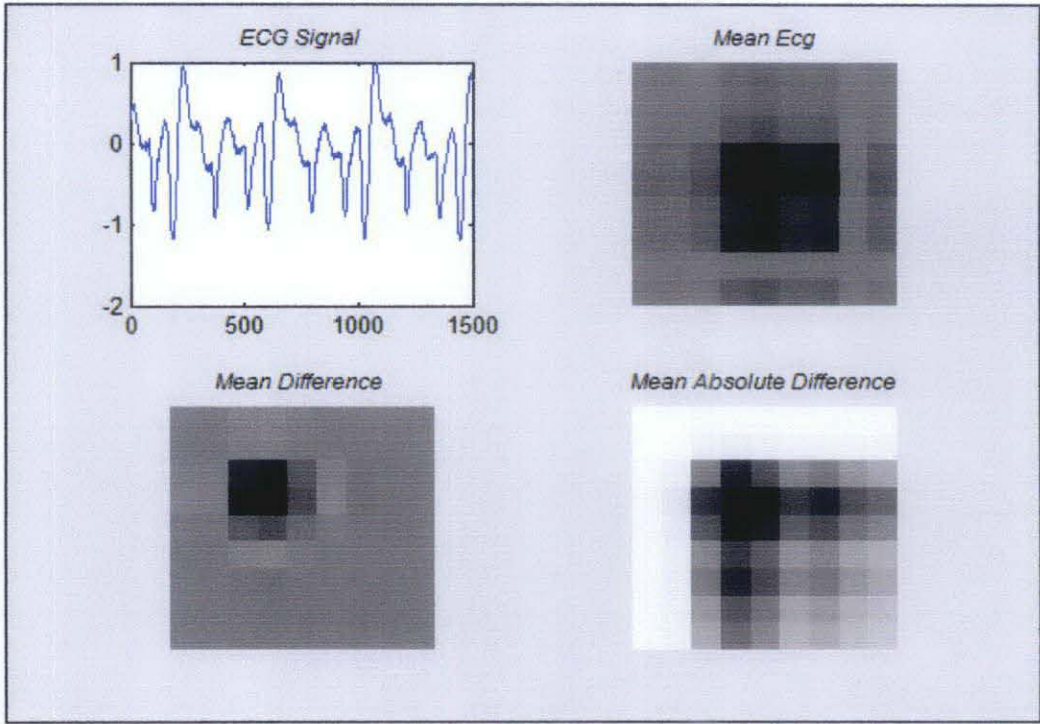


Figure 17: *Grayscale* Ventricular Fibrillation Data #2

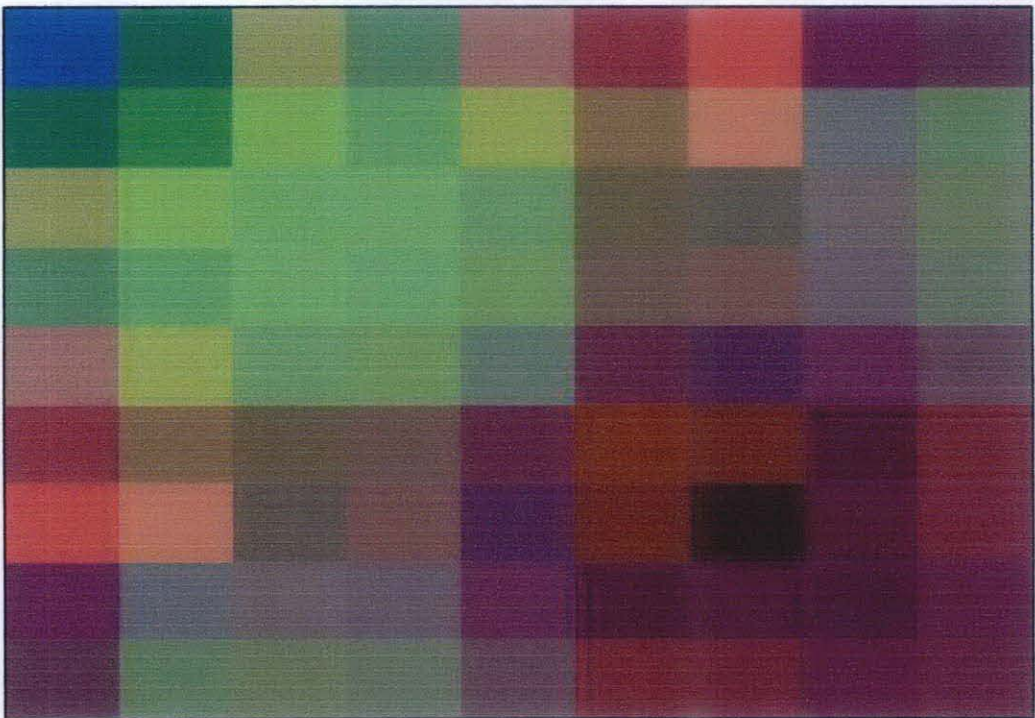


Figure 18: *RGB Scale* Ventricular Fibrillation Data #2

### 4.8.3 *Atrial Fibrillation*

In AF, the heart's electrical signal begins in a different part of the atria or the nearby pulmonary veins and is conducted abnormally. The signal doesn't travel through normal pathways, but may spread throughout the atria in a rapid, disorganized way. This can cause the atria to beat more than 300 times a minute in a chaotic fashion.

The abnormal signal from the SA node floods the AV node with electrical impulses. As a result, the ventricles also begin to beat very fast. However, the AV node can't conduct the signals to the ventricles as fast as they arrive, so even though the ventricles may be beating faster than normal, they aren't beating as fast as the atria. The atria and ventricles no longer beat in a coordinated fashion, creating a fast and irregular heart rhythm.

Consequent of this, instead of the body receiving a constant, regular amount of blood from the ventricles, it receives rapid, small amounts and occasional random, larger amounts, depending on how much blood has flowed from the atria to the ventricles with each beat. [9] Possible causes for Atrial Fibrillation are high blood pressure, coronary artery disease and alcohol abuse. The patient may experienced chest pain and heart attack while having AF. As concern the atrial fibrillation has nominated as the strongest risk factor of stroke.[10]

Figure 19 and 21 show both Atrial Fibrillation ECG data samples, Mecg, MD and MAD displayed in grayscale. While, figure 20 and 22 show all the data interpreted in RGB color display. As we previous case, the abnormal ECGs will show the reddish pattern at the output display.

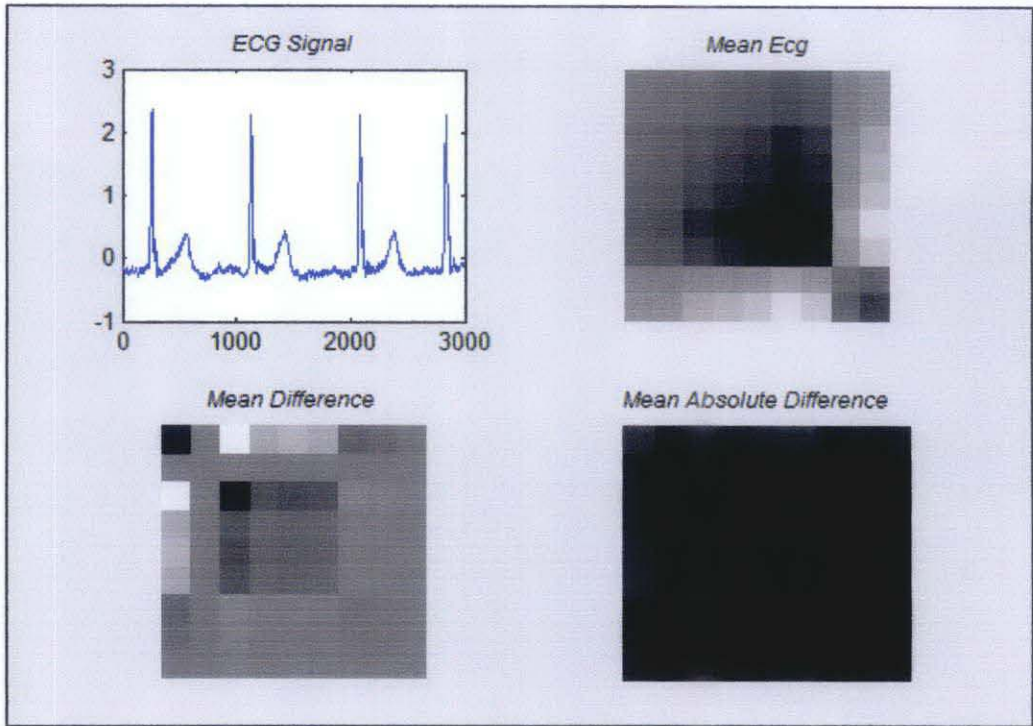


Figure 19: *Grayscale* Atrial Fibrillation Data #1

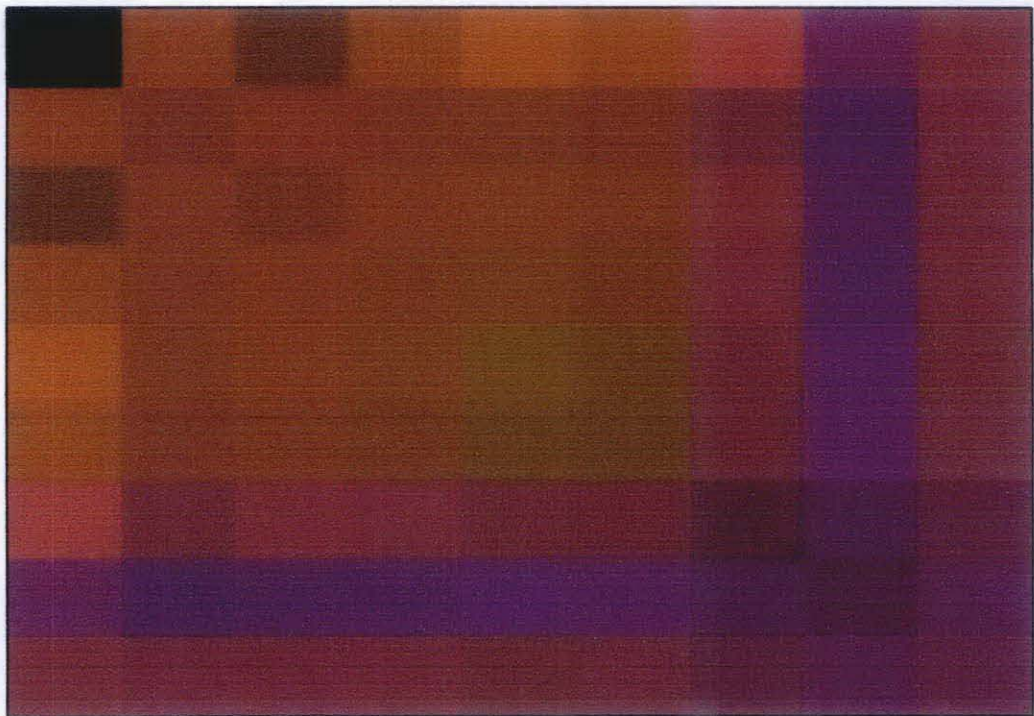


Figure 20: *RGB Scale* Atrial Fibrillation Data #1

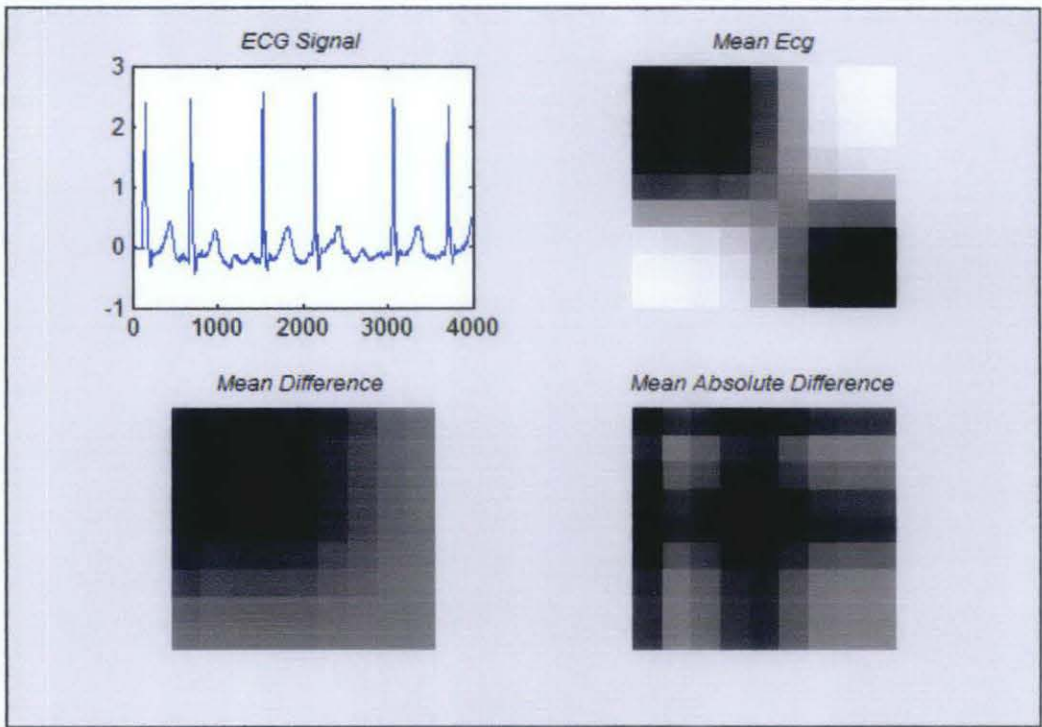


Figure 21: *Grayscale* Atrial Fibrillation Data #2

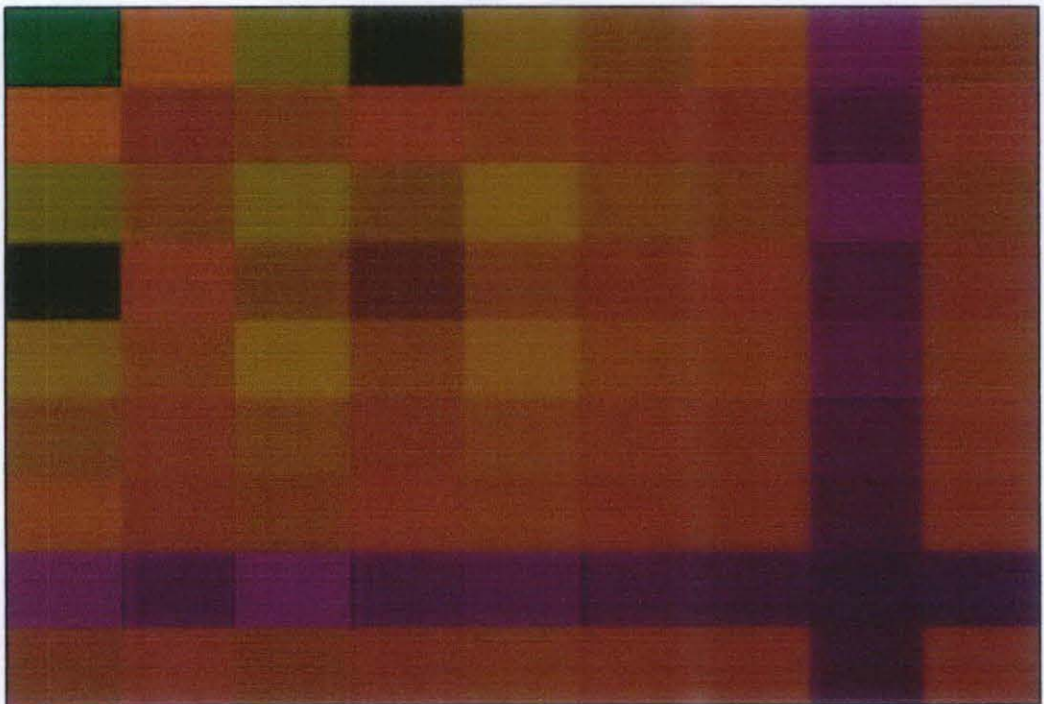


Figure 22: *RGB Scale* Atrial Fibrillation Data #2

#### 4.8.4 *Heart Failure*

Heart failure sounds frightening because it sounds like the heart just stops working. Do not be discouraged by the term heart failure-the heart has not stopped beating or pumping. Heart failure means the tissues of the body are temporarily not receiving enough blood and oxygen. Heart failure is an illness in which the pumping action of the heart becomes less and less powerful. That is, the heart does not pump blood as well as it should. When this happens, blood does not move efficiently through the circulatory system and starts to back up, increasing the pressure in the blood vessels and forcing fluid from the blood vessels into body tissues. [11]

Figure 23 and 25 show both Heart Failure ECG data samples, Mecg, MD and MAD displayed in grayscale. While, figure 24 and 26 show all the data interpreted in RGB color display. As we can observe, the abnormal ECGs will show the reddish pattern at the output display.

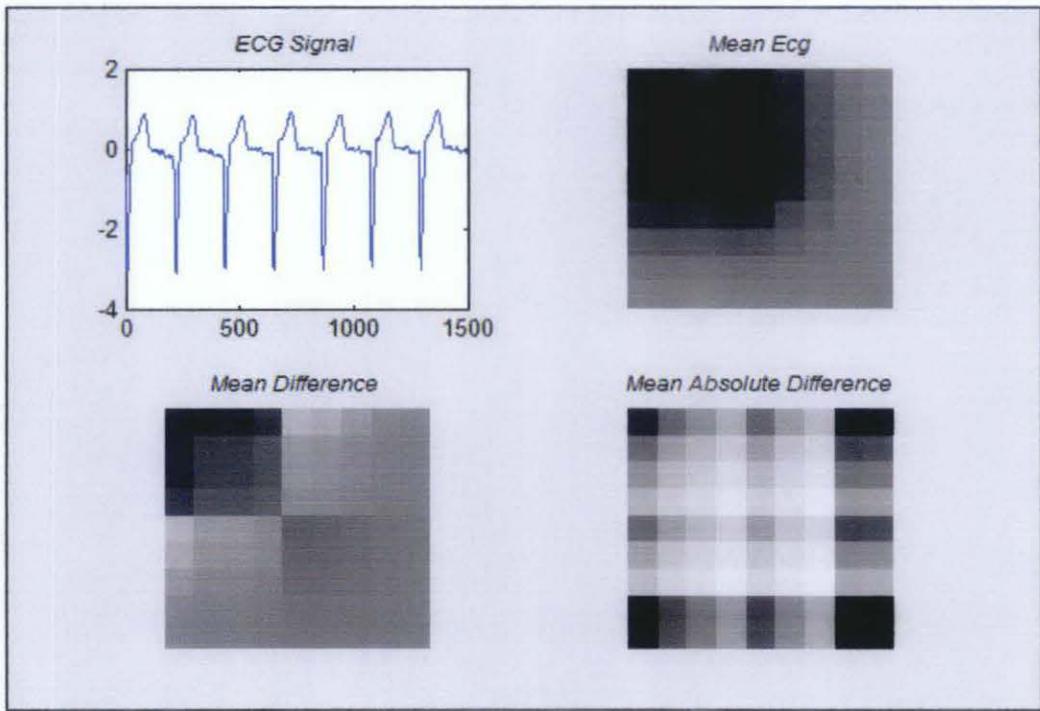


Figure 23: *Grayscale* Heart Failure Data #1

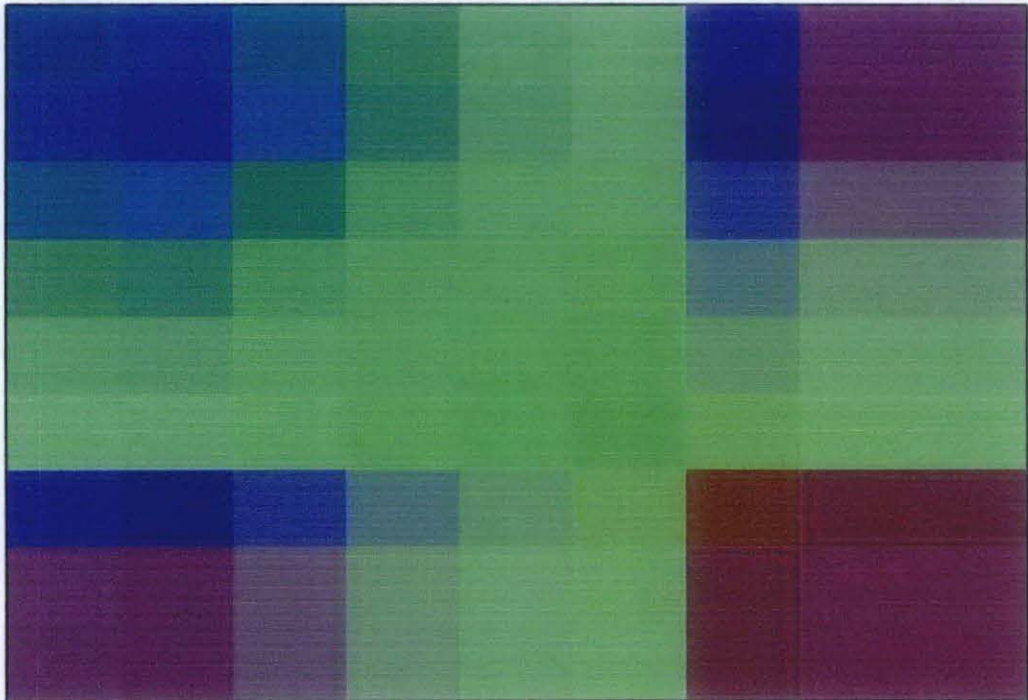


Figure 24: *RGB Scale* Heart Failure Data #1



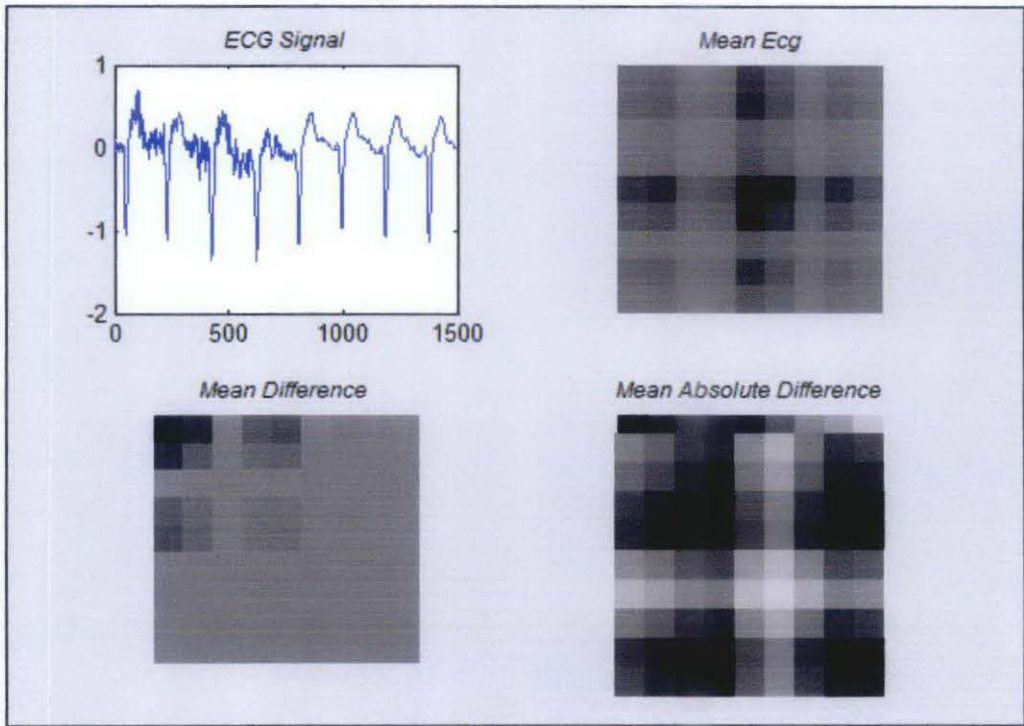


Figure 25: *Grayscale Heart Failure Data #2*

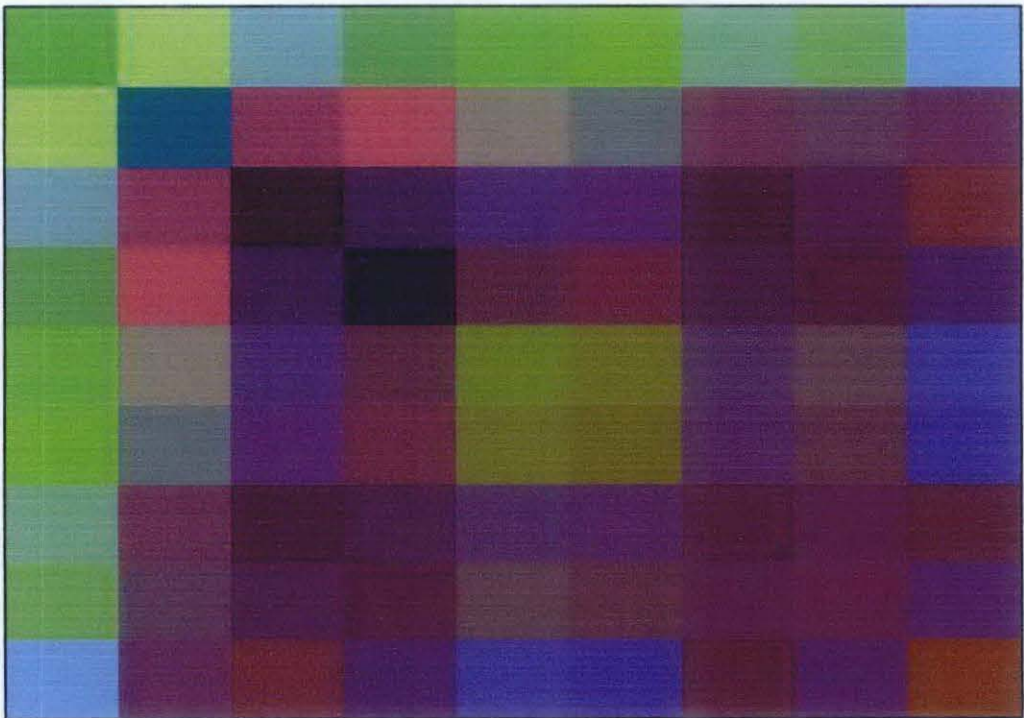


Figure 26: *RGB Scale Heart Failure Data #2*

## 4.9 Creating Graphical User Interface (GUIs)

This section will briefly explain on how to build an interactive user interface.

### 4.9.1 *What is GUI?*

A graphical user interface (GUI) is a graphical display that contains devices, or components, that enable a user to perform interactive tasks. To perform these tasks, the user of the GUI does not have to create a script or type commands at the command line. Often the user does not have to know the details of the task at hand.

The GUI components can be menus, toolbars, push buttons, radio buttons, list boxes, and sliders - just to name a few. In MATLAB, a GUI can also display data in tabular form or as plots, and can group related components.

### 4.9.2 *How does the GUI works?*

Each component, and the GUI itself, is associated with one or more user-written routines known as callbacks. The execution of each callback is triggered by a particular user action such as a button push, mouse click, selection of a menu item, or the cursor passing over a component. These callbacks is provided by the creator of the GUI.

### 4.9.3 *GUIDE, A brief Introduction*

GUIDE, the MATLAB Graphical User Interface development environment, provides a set of tools for creating graphical user interfaces (GUIs). These tools simplify the process of laying out and programming GUIs.

### 4.9.4 *Laying Out A GUI*

The GUIDE Layout Editor enables us to populate a GUI by clicking and dragging GUI components -- such as buttons, text fields, sliders, axes, and so on -- into the layout area. It also enables us to create menus and context menus for the GUI.

Other tools, which are accessible from the Layout Editor, enable us to size the GUI, modify component look and feel, align components, set tab order, view a hierarchical list of the component objects, and set GUI options.

#### 4.9.5 Programming the GUI

When we save our GUI layout, GUIDE automatically generates an M-file that we can use to control how the GUI works. This M-file provides code to initialize the GUI and contains a framework for the GUI callbacks -- the routines that execute in response to user-generated events such as a mouse click. Using the M-file editor, we can add code to the callbacks to perform the functions we want them to.

#### 4.10 CATCSIM

Using GUI Toolbox, from MATLAB Software, Computer-Aided Tomographic Cardiac Signal Mapping, (CATCSIM) has been designed to accommodate the user a friendly user interface. Using this features, the user are able to choose type of data to be simulated by the program. From this GUI, the user able to view, the graphical displays of Mean Absolute Difference, Mean Difference and Mean ECG signal. From this interface the user also able to view the RGB display as well from the right side of GUI. Instead of that, the component of colors contributed to the RGB display also can be observed from CATCSIM.

*Step 1:*

In order to observe the result from CATCSIM, firstly the user must select the data from the popup menu. For project testing, I have included 8 different types of data taken from the internet as the benchmark representing the healthy and unhealthy signals.

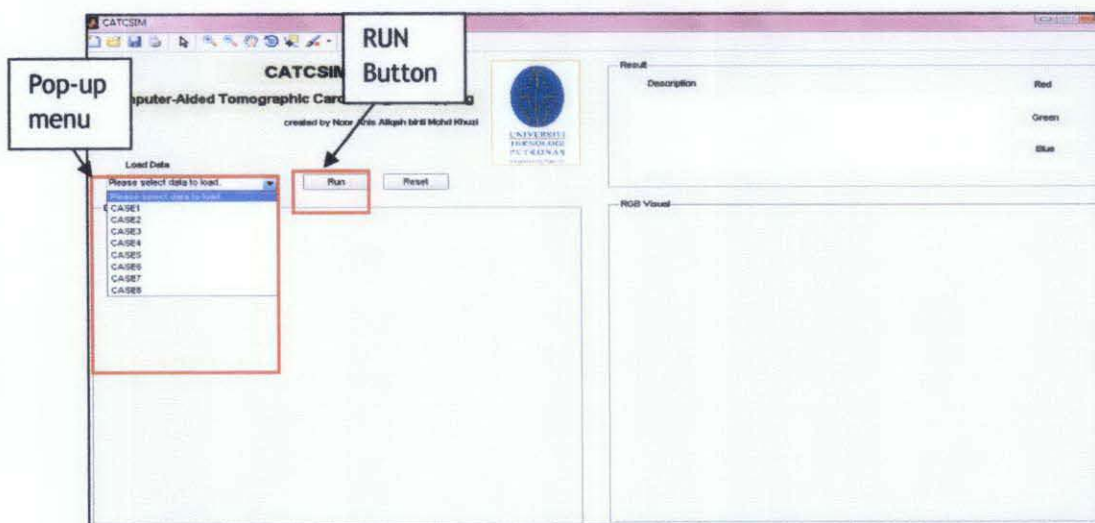


Figure 27: CATCSIM Interface

*Step 2:*

After that in order to view the result for the selected data, the user must press the RUN button. If the user presses the *RUN* button without selecting the data, the error message will be display.



Figure 28: Error message

*Step 3:*

After pressing the RUN button, the program will analyze the data and showing the result. The GUI will show us the color pattern continuously. On the left side of GUI, there will be 3 panels displaying the graphs of data Absolute Different, Different and the ECG signal.

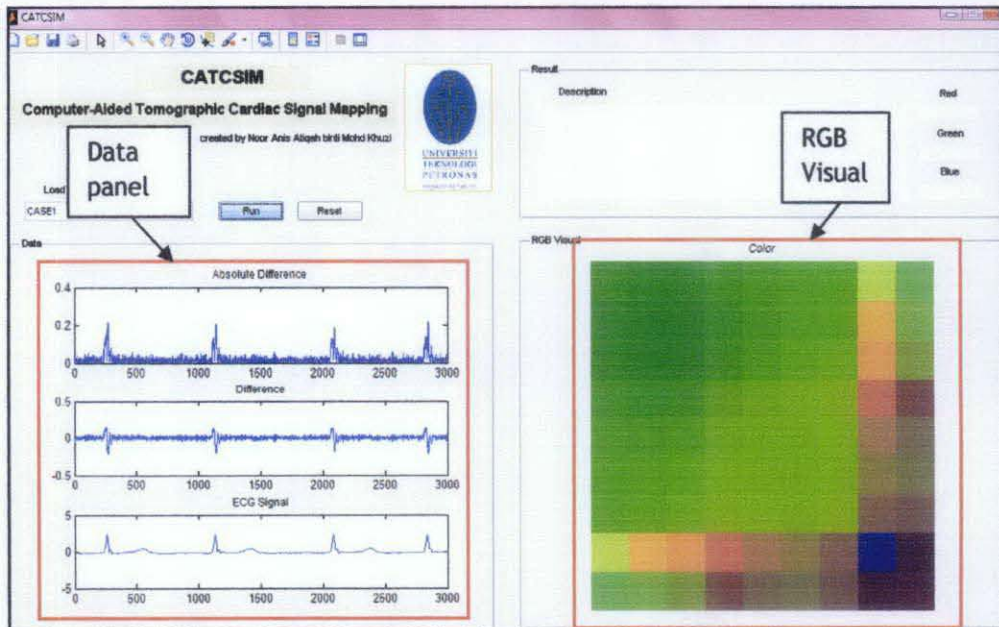


Figure 29: CATCSIM while in run mode.

Step 4:

It will take a few seconds for CATCSIM to stop processing the data. The time taken is depends on the data sizes. At the end, the user will able to view the total component of Red, Blue and Green contributed to the RGB display. The student added the description text for validation purpose.

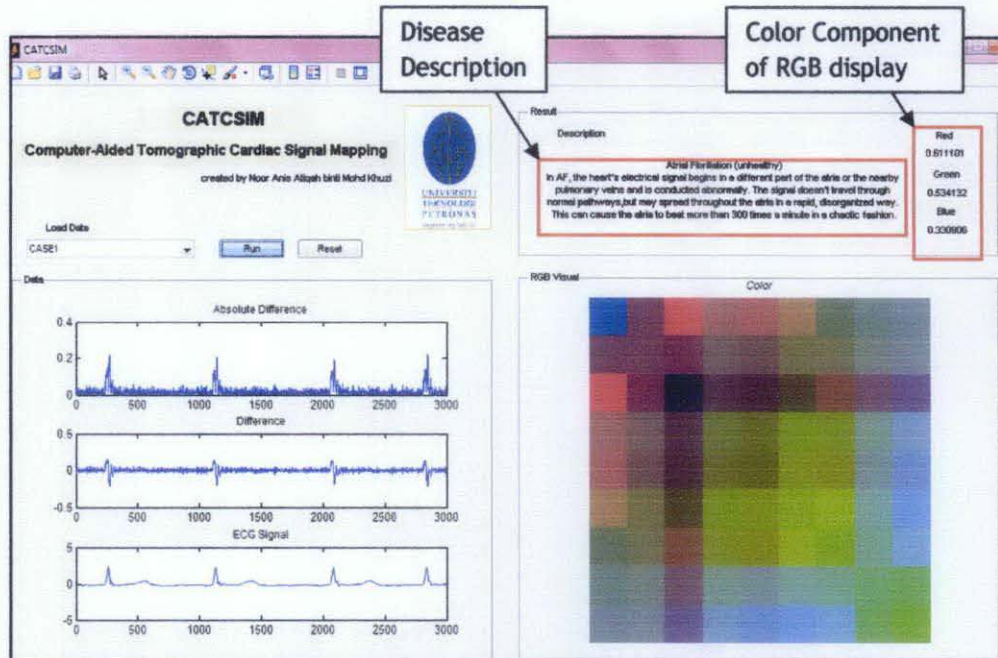


Figure 30: CATCSIM after finish analyzing the data.

*Step 5:*

When the program finish analyzing the data, the user able to zoom, pan, query the plot using the standard toolbar added to GUI. The user can reset the whole figures and data displaying on the GUI using the *RESET* button. Now the GUI is ready to analyze the new loading data.

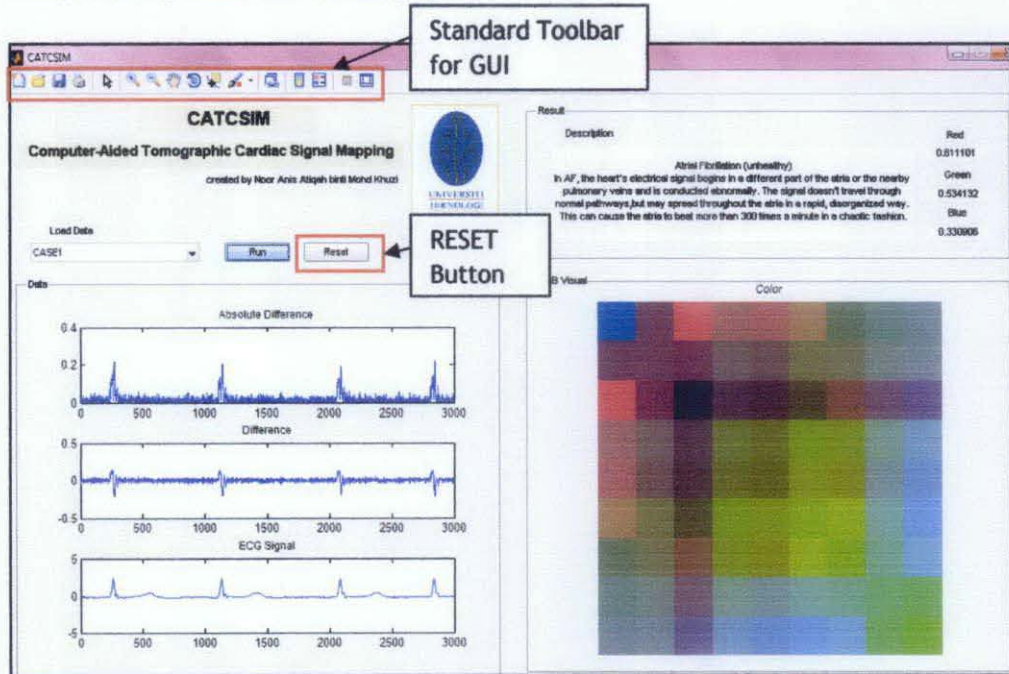


Figure 31: *RESET* button and standard GUI toolbar.

Another special features of this GUI program, it is also can be used by any computer without requirement of MATLAB software being installed. This means that this GUI can be a standalone program. In order able to use this program without installing MATLAB software the user must install Microsoft Net Framework and MCR installer.

At the end of the process, from 1D data of ECG, the user can identify whether the signal is healthy or unhealthy from the color cluster display on the CATCSIM. The table below shows the results of the simulation. Unhealthy signal will indicate highest frequency of red color, while for healthy person, the green component should be the highest compared to another components. Note that the color component values will varies from 0 to 1.

Table 2: Simulation results

Data Types/Signal Disease	Color Component		
	Red	Green	Blue
Atrial Fibrillation (Data #1)			
Atrial Fibrillation (Data #2)			
Ventricular Fibrillation (Data #1)			
Ventricular Fibrillation (Data #2)			
Heart Failure (Data #1)			
Heart Failure (Data #2)			
Normal Sinus Rhythm (Data #1)			
Normal Sinus Rhythm (Data #2)			

## **CHAPTER 5**

### **CONCLUSION AND RECOMMENDATIONS**

This is the final chapter for this report. This chapter will be divided into two parts, which are conclusion and recommendations. The conclusion will review of the project objectives followed by a brief discussion on the methodology and the result that was achieved. The recommendations are suggestions for future development of this research.

#### **5.1 Conclusion**

By completing this project, all the defined objectives should already been achieved. The basic fundamentals of ECGs have been fully understand before proceed with the project implementation. The important features of ECGs were defined and well understood. These parameters are the most important for the interpretation.

Algorithm used for translating ECGs has been studied deeply. The variation of the signals amplitude of each time sample has been observed by calculating the Difference and the Absolute Difference of ECG. The means value of ECGs, Difference and Absolute Difference ECGs are being calculate to perform the RGB scale transformation.

After defining the algorithm, project implementation was begun using the MATLAB. This software is a very powerful tool for analyzing and simulation. Now the student is able to upload the ECG signal and find the Difference and Absolute Difference values. The student is also able to display the graph for the means value for all the windows size for comparison purpose.



After computing the mean of ECG, mean difference and mean absolute difference of ECG, the student able to transform the 3 data matrices into grayscale mapping using the ceil function. For each set of matrices, the system designed able to produce grayscale mapping for easier interpretation.

Once done with the 2D grayscale mapping, we move to further enhancement; 3D color RGB scale mapping. This step will make the ECG interpretation will be more interactive compared to the grayscale. The interpretation of this color pattern still needs to be improvising to determine the exact patterns. Several tests still have to be conducted in order to prove the project validity. There are eight data have been used to test the validity of this project. Two of them are healthy signals, while the rest are unhealthy signals. From the output display observation, the healthy signals should produce greenish pattern of RGB display. For unhealthy cases, the output should produce reddish color pattern.

The final phase of this project is providing the interactive GUI while running the simulation. The GUI should consist of the simulation data series, RGB display, component of RGB, and the MAD, MD including Mecg for each average window.

After finish this project, 3D RGB Color display of ECGs interpretation is obtained using MATLAB programming. The concept of this project may be applicable to the real world application.

As the conclusion, after defining the proper objectives, scope of study and methodology, the project has been successfully finished within the given time frame. The ECG interpretation has been improvised using the RGB color display method. Using this approach, the interpretation will be more interesting due to the color patterns generated. These two types of simulations, 2D grayscale and 3D Color scale are applicable for all types of ECG.

## **5.2 Recommendations**

Due to limited resources and time constraints, the study of this project is not fully completed. Several points should be taken into consideration in order to improve the performance of this project. Therefore, the following suggestions are recommended for further action:

### *5.2.1 Online ECG analysis*

This project only focus only on analyzing the ECG signals obtained from the internet database as the benchmark. The interpretation is not connected directly to the machine to interpret the signal immediately after the data being collected. This project only applicable to the offline ECGs source. However, in order to improvised, the online ECG analysis should be implemented to reduce the complexity of the ECGs interpretation.

### *5.2.2 Tool Used*

Instead of using MATLAB, the other tool should be used to implement this project. Several programming languages can be intergrated with MATLAB to give a better implementation. C/C++ or even JAVA are among the other popular programming language that should be used to enhance the functionality of the project.

### *5.2.3 Designing Full System*

Until this stage, this is better for the project to be improved by developeping a full system, hardware and software. The software developed in MATLAB should be intergrated with the designed hardware to analyze ECG.

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## **APPENDICES**

**APPENDIX A**  
**MATLAB Code for analyzing ECG signal**

```

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Modelling Cardiac Signal as Tomographic Mapping
%Author:Noor Anis Atiqah Mohd Khuzi
%Supervised By: Dr. Vijanth Sagayan Asirvadam
%data used= ECG.dat
%This MATLAB codes are used to analyze the signal using Mean value.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

```

```

function gra_update(MAD, MD, Mecg)

load('ECG.dat');
Ecgsignal = ECG(1:12000);
[r,c] = size(Ecgsignal);
ADIFF = [];
ADiff0 = 0;
DIFF = [];
Diff0 = 0;

%Calculate Diff and ADiff of ECG signal
for i = 2:r
    ADIFF =[ADIFF;ADiff0];
    DIFF =[DIFF;Diff0];
    ADiff0 =abs(Ecgsignal(i)- Ecgsignal(i-1));
    Diff0 =(Ecgsignal(i)- Ecgsignal(i-1));
end

%Calculate MeanECG, MeanDiff, and MeanADiff for window size = 2
winMecg2 = [];
winMDiff2 = [];
winMADiff2 = [];

    for k = 1:r-2
        meanECG2 = mean(Ecgsignal(k:k+1));
        winMecg2 = [winMecg2; meanECG2];

        meanDIFF2 = mean(DIFF(k:k+1));
        winMDiff2 = [winMDiff2; meanDIFF2];

        meanADIFF2 = mean(ADIFF(k:k+1));
        winMADiff2 = [winMADiff2; meanADIFF2];

    end

%Calculate MeanECG, MeanDiff, and MeanADiff for window size = 4
winMecg4 = [];
winMDiff4 = [];
winMADiff4 = [];

    for k = 1:r-4
        meanECG4 = mean(Ecgsignal(k:k+3));
        winMecg4 = [winMecg4; meanECG4];

        meanDIFF4 = mean(DIFF(k:k+3));
        winMDiff4 = [winMDiff4; meanDIFF4];
    end

```

```

        meanADIFF4 = mean(ADIFF(k:k+3));
        winMADiff4 = [winMADiff4; meanADIFF4];

    end

%Calculate MeanECG, MeanDiff, and MeanADiff for window size = 8
winMecg8 = [];
winMDiff8 = [];
winMADiff8 = [];

    for k = 1:r-8
        meanECG8 = mean(EcgSignal(k:k+7));
        winMecg8 = [winMecg8; meanECG8];

        meanDIFF8 = mean(DIFF(k:k+7));
        winMDiff8 = [winMDiff8; meanDIFF8];

        meanADIFF8 = mean(ADIFF(k:k+7));
        winMADiff8 = [winMADiff8; meanADIFF8];

    end

%Calculate MeanECG, MeanDiff, and MeanADiff for window size = 16
winMecg16 = [];
winMDiff16 = [];
winMADiff16 = [];

    for k = 1:r-16
        meanECG16 = mean(EcgSignal(k:k+15));
        winMecg16 = [winMecg16; meanECG16];

        meanDIFF16 = mean(DIFF(k:k+15));
        winMDiff16 = [winMDiff16; meanDIFF16];

        meanADIFF16 = mean(ADIFF(k:k+15));
        winMADiff16 = [winMADiff16; meanADIFF16];

    end

%Calculate MeanECG, MeanDiff, and MeanADiff for window size = 32
winMecg32 = [];
winMDiff32 = [];
winMADiff32 = [];

    for k = 1:r-32
        meanECG32 = mean(EcgSignal(k:k+31));
        winMecg32 = [winMecg32; meanECG32];

        meanDIFF32 = mean(DIFF(k:k+31));
        winMDiff32 = [winMDiff32; meanDIFF32];

        meanADIFF32 = mean(ADIFF(k:k+31));
        winMADiff32 = [winMADiff32; meanADIFF32];

    end
end

```

```

%Calculate MeanECG, MeanDiff, and MeanADiff for window size = 64
winMecg64 = [];
winMDiff64 = [];
winMADiff64 = [];

for k = 1:r-64
    meanECG64 = mean(EcgSignal(k:k+63));
    winMecg64 = [winMecg64; meanECG64];

    meanDIFF64 = mean(DIFF(k:k+63));
    winMDiff64 = [winMDiff64; meanDIFF64];

    meanADIFF64 = mean(ADIFF(k:k+63));
    winMADiff64 = [winMADiff64; meanADIFF64];

end

%Calculate MeanECG, MeanDiff, and MeanADiff for window size = 128
winMecg128 = [];
winMDiff128 = [];
winMADiff128 = [];

for k = 1:r-128
    meanECG128 = mean(EcgSignal(k:k+127));
    winMecg128 = [winMecg128; meanECG128];

    meanDIFF128 = mean(DIFF(k:k+127));
    winMDiff128 = [winMDiff128; meanDIFF128];

    meanADIFF128 = mean(ADIFF(k:k+127));
    winMADiff128 = [winMADiff128; meanADIFF128];

end

%Calculate MeanECG, MeanDiff, and MeanADiff for window size = 256
winMecg256 = [];
winMDiff256 = [];
winMADiff256 = [];

for k = 1:r-256
    meanECG256 = mean(EcgSignal(k:k+255));
    winMecg256 = [winMecg256; meanECG256];

    meanDIFF256 = mean(DIFF(k:k+255));
    winMDiff256 = [winMDiff256; meanDIFF256];

    meanADIFF256 = mean(ADIFF(k:k+255));
    winMADiff256 = [winMADiff256; meanADIFF256];

end

%Calculate MeanECG, MeanDiff, and MeanADiff for window size = 512
winMecg512 = [];
winMDiff512 = [];

```



```

winMADiff512 = [];

for k = 1:r-512
    meanECG512 = mean(EcgSignal(k:k+511));
    winMecg512 = [winMecg512; meanECG512];

    meanDIFF512 = mean(DIFF(k:k+511));
    winMDiff512 = [winMDiff512; meanDIFF512];

    meanADIFF512 = mean(ADIFF(k:k+511));
    winMADiff512 = [winMADiff512; meanADIFF512];

end

ADIFF = ADIFF(1:10000);
DIFF = DIFF(1:10000);
EcgSignal = EcgSignal(1:10000);

figure(1)
subplot(3,1,1)
plot(ADIFF);
title('Absolute Difference','FontSize',9)
subplot(3,1,2)
plot(DIFF);
title('Difference','FontSize',9)
subplot(3,1,3)
plot(EcgSignal);
title('ECG Signal','FontSize',9)

winMADiff2 = winMADiff2(1:10000);
winMDiff2 = winMDiff2(1:10000);
winMecg2 = winMecg2(1:10000);

winMADiff4 = winMADiff4(1:10000);
winMDiff4 = winMDiff4(1:10000);
winMecg4 = winMecg4(1:10000);

winMADiff8 = winMADiff8(1:10000);
winMDiff8 = winMDiff8(1:10000);
winMecg8 = winMecg8(1:10000);

winMADiff16 = winMADiff16(1:10000);
winMDiff16 = winMDiff16(1:10000);
winMecg16 = winMecg16(1:10000);

winMADiff32 = winMADiff32(1:10000);
winMDiff32 = winMDiff32(1:10000);
winMecg32 = winMecg32(1:10000);

winMADiff64 = winMADiff64(1:10000);
winMDiff64 = winMDiff64(1:10000);
winMecg64 = winMecg64(1:10000);

winMADiff128 = winMADiff128(1:10000);
winMDiff128 = winMDiff128(1:10000);
winMecg128 = winMecg128(1:10000);

```

```
winMADiff256 = winMADiff256(1:10000);
winMDiff256 = winMDiff256(1:10000);
winMecg256 = winMecg256(1:10000);

winMADiff512 = winMADiff512(1:10000);
winMDiff512 = winMDiff512(1:10000);
winMecg512 = winMecg512(1:10000);

MAD = [winMADiff2 winMADiff4 winMADiff8 winMADiff16 winMADiff32
winMADiff64 winMADiff128 winMADiff256 winMADiff512];

MD = [winMDiff2 winMDiff4 winMDiff8 winMDiff16 winMDiff32 winMDiff64
winMDiff128 winMDiff256 winMDiff512];

Mecg = [winMecg2 winMecg4 winMecg8 winMecg16 winMecg32 winMecg64
winMecg128 winMecg256 winMecg512];

end
```

**APPENDIX B**  
**MATLAB Code for Color Transformation**

```

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Modelling Cardiac Signal as Tomographic Mapping
%Author:Noor Anis Atiqah Mohd Khuzi
%Supervised By: Dr. Vijanth Sagayan Asirvadam
%data used= ECG.dat
%This MATLAB codes are used to transform ECG data analysis to
  colour mapping.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

```

```

XX = [];
YY = [];
ZZ = [];

```

```

for n = 1:700
    img = imread('ECGimage.jpg');
    img1 = imread('ECGimage.jpg');
    img2 = imread('ECGimage.jpg');
    imgc = imread('ECGimage.jpg');

```

```

    x = MAD(n,:);
    xx = x'*x;
    mx = max(max(xx));
    xxn = xx./mx;

```

```

    xn = x/max(x);
    XX = [XX xn'];

```

```

    y =MD(n,:);
    YY = y'*y;
    my = max(max(yy));
    yyn = yy./my;

```

```

    yn = y/max(abs(y));
    ynS = 0.5 + 0.5*(yn);
    YY = [YY ynS'];

```

```

    z =Mecg(n,:);
    zz = z'*z;
    mz = max(max(zz));
    zzn = zz./mz;

```

```

    zn = z/max(abs(z));
    znS = 0.5 + 0.5*(zn);
    ZZ = [ZZ znS'];

```

```

for m = 1:x
    for idx = 1:m
        for idxx = 1:idx
            clrIDX = xxn(idx,idxx);
            clrIDY = yyn(idx,idxx);
            clrIDZ = zzn(idx,idxx);

```

```

%color transformation
%Red component
imgc(1+40*(idx-1):40+40*(idx-1),1+40*(idxx-1):40+40*(idxx-1),2) =
(255 - 255*clrIDX);
imgc(1+40*(idxx-1):40+40*(idxx-1),1+40*(idx-1):40+40*(idx-1),2) =
(255 - 255*clrIDX);
%Green component
imgc(1+40*(idx-1):40+40*(idx-1),1+40*(idxx-1):40+40*(idxx-1),1)
=(125 - 125*clrIDY);
imgc(1+40*(idxx-1):40+40*(idxx-1),1+40*(idx-1):40+40*(idx-1),1)
=(125 - 125*clrIDY);
%Blue component
imgc(1+40*(idx-1):40+40*(idx-1),1+40*(idxx-1):40+40*(idxx-1),3) =
(125 - 125*clrIDZ);
imgc(1+40*(idxx-1):40+40*(idxx-1),1+40*(idx-1):40+40*(idx-1),3) =
(125 - 125*clrIDZ);
        end
    end
end

imwrite(img,['imgMAD' num2str(n) '.jpeg'])
imwrite(img1,['imgMD' num2str(n) '.jpeg'])
imwrite(img2,['imgMecg' num2str(n) '.jpeg'])
imwrite(imgc,['imgColor' num2str(n) '.jpeg'])

%Displaying grascale transformation.
figure(11)
subplot(2,2,1)
plot(EcgSignal)
title('\it{ECG Signal}','FontSize',9)
subplot(2,2,2)
imshow(img2);
title('\it{Mean Ecg}','FontSize',9)
subplot(2,2,3)
imshow(img1);
title('\it{Mean Difference}','FontSize',9)
subplot(2,2,4)
imshow(img);
title('\it{Mean Absolute Difference}','FontSize',9);

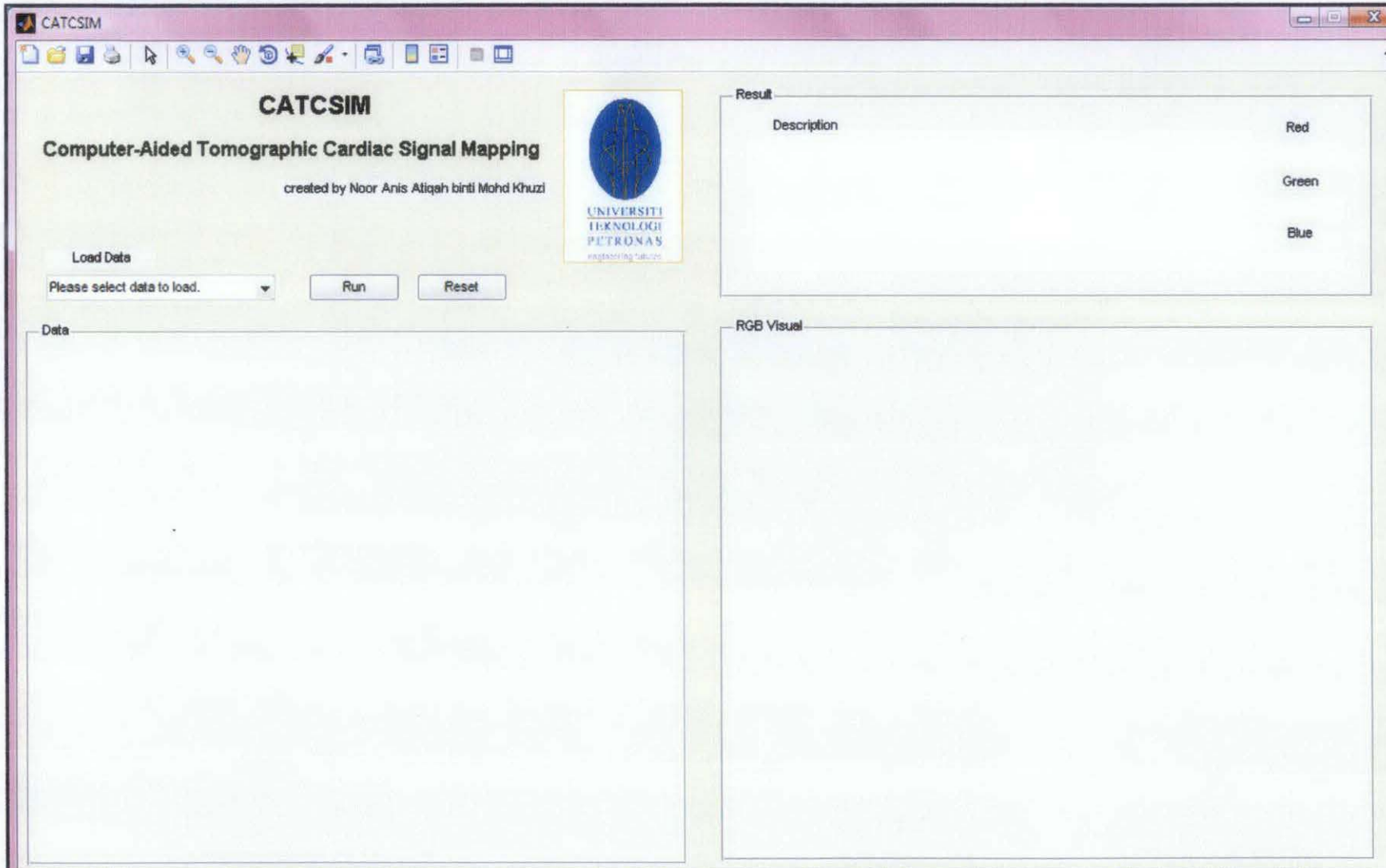
%Displaying Colour Transformation
figure(12)
imshow(imgc);
title('\it{Color}','FontSize',9)

end

```

## **APPENDIX C**

### **Sample of Graphic User Interface**



## **APPENDIX D**

### **Final Year Project Schedule**



## Final Year Project Part I (FYP I) Schedule

Semester: January 2009

No.	Detail/Week	1	2	3	4	5	6	7	8	9	Mid- Semester Break					10	11	12	13	14				
1	Selection of Project Topic																							
2	Preliminary Research Work																							
3	Submission of Preliminary Report				●																			
4	Seminar 1 (optional)																							
5	Project Work																							
6	Submission of Progress Report								●															
7	Seminar 2 (compulsory)																							
8	Project work continues																							
9	Submission of Interim Report Final Draft																						●	
10	Oral Presentation																		●					

Indication:

- 
- Suggested milestone
  
- 
- Process

## Final Year Project Part II (FYP II) Schedule

Semester: July 2009

No.	Detail/ Week	1	2	3	4	5	6	7	8	9		10	11	12	13	14	
1	Project Work Continue										Mid-Semester Break						
2	Submission of Progress Report																
3	Seminar																
4	Project work continue																
5	Poster Exhibition																
6	Submission of Dissertation (soft bound)																
7	Oral Presentation																
8	Submission of Project Dissertation (Hard Bound)																

Indication:



Suggested milestone

Process