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Biometric identification based on ECG waveform

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Dedication

We would like to dedicate this thesis to our loving parents, teachers who gave us everything they had to facilitate our success. and every one who help us to finish this project.

Acknowledgements

We would like to express our heartfelt gratitude to our advisor Doctor Mousa Alrefayah for his constant encouragement and guidance throughout the course of our bachelors study and all the stages of the writing of this thesis. Without his instruction, this thesis work could not have reached its present form. His editorial advice was essential for the completion of this thesis. We feel privileged to have had the opportunity to study under him. You have trusted us, you kept challenging us to do our best. And we hope that we made you proud of us as we always proud of you. We also would like to thank everyone who has helped us along the way.At last, we should mention that this graduation project has been supported by the Deanship of Graduate Studies and Scientific Research through "Distinguished Graduation Projects Fund".

Abstract

Our project presents a new biometric for individual verification and authentication. It improves the better security protection and confidentiality of security information without the need for passwords that can replicated or stolen. We used ECG (Electrocardiogram) waveform for individual verification, because it varies from one person to another. It is a new and abetter biometric recognition for more security from the other biometric recognition like iris, fingerprint. It identifies user by verifying his unique ECG waveform. It also can unlock user's accounts and devices. If someone else wears the device, it does not work.

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Chapter 1

Introduction

1.1 Overview

This chapter talks about the description of the project idea, objectives, the important of the project, and project scope.

1.2 Project idea description

Our project presents a new biometric for individual verification and authentication .It is a solution for security protection and confidentiality of security information without the need for passwords that can be replicated or stolen.
The Experts found that the ECG (Electrocardiogram) waveform varies from one person to other, depend on the heart size, leads locations, and heart muscle strength .It can be used for individual verification.

The project is anew portable device like bracelet or watch depends on biometric electrocardiogram (ECG) waveform for individual recognition, it reads ECG waveform via an electrocardiogram sensor, and this is more secure from other biometric recognition such as iris, fingerprint, it can unlock user's accounts and devices, just by its presence.If someone else wears the device, it doesn't work.

The portable device consists of ECG sensor, processor, ECG electrode attach user's body , the ECG waveform will be read by ECG sensor.

The portable device uses Bluetooth to transmit password code to user's devices.

1.3 Motivations

1. Designing and implementing a security system using ECG identification for companies, organizations, offices, homes, and banks etc.

2. Giving the administrator easy way to supervis the employees in companies, and ensure of employee time of work, this system protects companies from any stranger person (can be used for controlling who can enter the company or the organizations and who can not) .

3. Many offices use the traditional system to record information about their employees which leads to inefficiently and wasting in time moreover the traditional system like iris, fingerprint has many drawbacks.It's unprofessional and its easily lost.

4. The system can used in people home, its let user use his unique shape of ECG waveform to authenticate his identity, allowing user to wirelessly take control of his computer, user's smart phone, user's car and so much more .

5. Person can learn new information through this system, and can work in new environmental.

6. Person with this system become more comfortable about all of his security information and all of his devices.

1.4 Project scope

1.4.1 Design objectives

The proposed project aims to:

1. Design and build a new portable device to unlocks user's accounts and devices.

2. Introduce a solution for the protection and confidentiality of our information without the need for passwords that can be penetrate or replicated or stolen.

3. Try a new biometric authentication based on ECG waveform identification.

4. Overcome limitations of traditional biometric authentication like iris, fingerprint.

1.4.2 System requirements

The proposed project will :

1. Identify user when he wear the portable device.
2. Have a hardware interface that is easy for user to interact with.
3. Efficiently compare the ECG reading waveform with ECG stored in data base.
4. Efficiently store the ECG waveform.
5. Guarantee that the user is the real one.

1.4.3 Assumptions

There are some assumption in the project:

1. The user doesn't have any heart disease.
2. The sensor which read the ECG is sensitive and give accurate result and differences between the people.

In order to achieve the aforementioned objectives and requirements we need the following hardware and software components:

- ECG electrodes :to read user's ECG waveform.it is a hardware interface that is easy for user to interact with.
- E-health sheild :to take ECG signal from ECG electrodes and make filtering and amplifying on it .
- Aurdino Mega :used for reading ECG signal from E-health sheild.
- Aurdino Due :used for comparing ECG signal and convert it to digital.
- Bluetooth :for transmiting ECG signal to user's devices or account.
- MATLAB :for test the code .
- Aurdino code :for for implementing the overall project..
- LATEX :for writing the documentation.
- Visio program :to draw the require block diagram in project.
- For C charp application of the project.

1.5 Project contents

This section summarizes briefly what each chapter explains.

Chapter One: Introduction.

This chapter gives the description of the project idea, objective and important of project and project scope.

Chapter Two: Literature review and theoretical background.

In this chapter we discuss the theoretical background and literature review that are related to the main idea of the project.

Chapter Three: Project management plane.

The information discused in this chapter is about the project management plane, it describe task set, risk, project resource, the cost and time estimation of the project.

Chapter Four: Software requirement specification.

This chapter presents the requirement description of the project; it explains the requirement as scenarios using Use-case diagram, class responsibilities, collaborator, class hierarchies and relationships.

Chapter Five: System design

This chapter talks about the object relational module for software component, state behavioral, class and object design, the software and hardware interface design.

Chapter Six: Hardware and software implementation.

This chapter explains in detailed steps and procedure of programming every used components in this project either hardware or software components.

Chapter Seven: Test

This chapter displays the test of the project.

Chapter Eight: Conclusion and Recommendations.

This chapter includes some recommendations for moving forward in utilizing our project to benefit the medical field.

1.6 Summary

This chapter talked about the description of the project idea, objectives, importantce, and the project scope.

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Chapter 2

Literature review and theoretical background

2.1 Overview

This chapter talks about theoretical background of the system, additionally, literature related to the biometric identification system based on electrocardiogram data.

2.2 Theoretical background

This section talks about theoretical background behind the electrocardiogram (ECG), furthermore, the main principles of the biometric definition.

2.2.1 Biometric

Biometrics is the science and technology of measuring and analyzing biological data.It is usually associated with the use of unique physiological characteristic to identify an individual, such as ECG waveform, DNA, fingerprints, eye retinas, irises, voice patterns, facial patterns and hand measurements for authentication purposes[1].
Authentication by biometric verification is becoming increasingly common incorporate in public security systems, consumer electronics and point of sale (POS) applications.In addition to security, the driving force behind biometric verification has been convenience[1].

- **Biometric advantages**

1. Increase security, provide a convenient and low cost of security.
2. Eliminate problems caused by lost IDs,by using physiological attributes.
3. Reduce password administration costs.
4. Replace hard to remember passwords which may be shared or observed.
5. Make it possible, automatically, to know WHO did WHAT, WHERE and WHEN!

- **Biometric disadvantages**

1. More expensive.
2. Some users may reject biometrics as a whole, seeing it as an invasion of privacy.
3. Biometric identification machines are not always entirely accurate.

2.2.2 Electrocardiogram (ECG)

An electrocardiogram (ECG) signal describes the electrical activity of the heart. The electrical activity is related to the impulses that travel through the heart.It provides information about the heart rate, rhythm.Normally, ECG is recorded by attaching a set of electrodes on the body surface such as chest, neck, arms, and legs.These electrodes measure the magnitude and direction of electrical currents in the heart during each heartbeat.[2] typical ECG wave consists of a P wave, a QRS complex, and a T wave.See figure (2.1).

The P wave

Reflects the sequential depolarization (depolarization is when a cell membrane's charge becomes positive to generate an action potential.This is usually caused by positive sodium and calcium ions going into the cell[3])of the right and left atria.[4]

The QRS wave

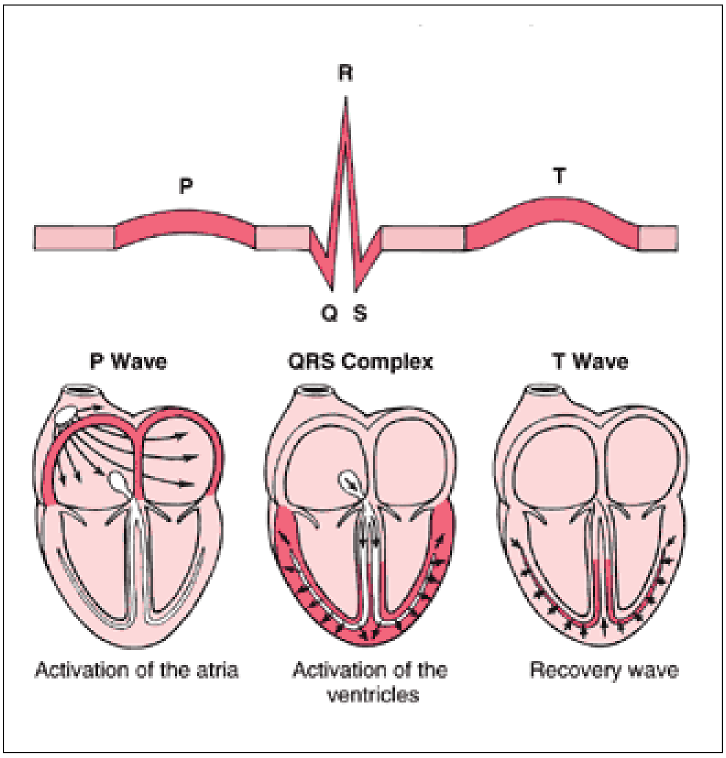

Figure 2.1: ECG reading wave.[5]

Complex corresponds to depolarization of the right and left ventricles,it has the largest amplitude of the ECG waveforms; the frequency content of the QRS complex is considerably higher than that of the other ECG waves[4].

The T wave

Reflects ventricular depolarization; the position of the T wave is strongly dependent on heart rate, becoming narrower and closer to the QRS complex at rapid rates [4].

- **ECG leads**

  The word lead has two meanings in electrocardiography:

  1. The wire that connects an electrode to the electrocardiograph.
  2. A combination of electrodes that form an imaginary line in the body along which the electrical signals are measured.

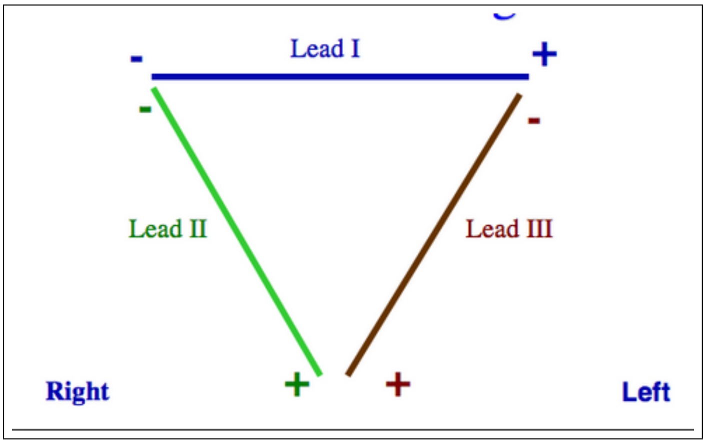

Figure 2.2: Einthoven's triangle. [7]

A lead records the electrical signals of the heart from a particular combination of recording electrodes which are placed at specific points on the user's body.[6]

- **Bipolar limb leads**

The bipolar limb leads are those designed Lead I, Lead II, and Lead III and form what is called Einthoven's Triangle.See figure(2.2).

Lead I :it is a dipole with the negative electrode on the right arm and the positive electrode on the left arm.

Lead II :It is a dipole with the negative electrode on the right arm and the positive electrode on the left leg.

Lead III :It is a dipole with the negative electrode on the left arm and the positive electrode on the left leg. [6]

- **Heart rate.**

Heart rate is the number of heart beats per unit time, usually per minute.The heart rate based on the number of contractions of the ventricles(the lower chambers of the heart).It can vary with as the body's need for oxygen changes, such as during excercise or sleep. the measurement of the heart rate is used by medical professionals to assist in the diagnosis and tracking of medical conditions.Heart rate is measured by finding the pulse of the body.[8]

2.2.3 The heart's electrical system

The synchronized electrical sequence of the heart is initiated by the SA (sinoatrial node) node.The firing of the SA node sends out an electrical impulse via its neurons to the right atrium, left atrium, and AV node (atrioventricular node) simultaneously.

Since the right atrium is closer to the SA node, it depolarizes first, resulting in pumping action by the right atrium before the left atrium.

At the AV node, the impulse is delayed to allow for the ventricles to fill up with blood.After the delay, the AV node sends the impulse to the Bundle of His and the Purkinje fibers.

This triggers the contraction of the ventricles to send blood either to the lungs or out to the body[9]. The depolarization and repolarization of the SA node and the other elements of the heart's electrical system produces a strong pattern of voltage change, this can be measured with electrodes on the skin.Voltage measurements on the skin are called ECG[9].See figure(2.3)

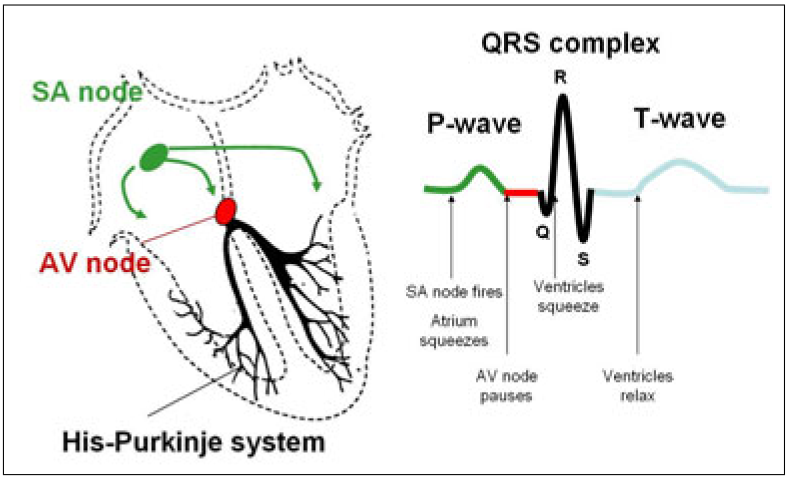

Figure 2.3: The heart's electrical system.[10]

2.2.4 Components of the heart's electrical system

Generally, ECG signal may attached with noise that are in the same frequency band, so we need to process the raw ECG signals, to produce a new ECG signal by filtering and amplifying, respectively.

2.2.4.1 Filtering

The ECG signals are subject to many different kinds of noise internally and externally, so it must be filtered to get the desired signal noise free.E-health sheild sensor has been used for ECG signal.As an alternative, Arduino code can do filtering tasks that can be implemented.

2.2.4.2 Amplifing

ECG signals vary from the microvolt to the millivolt range.Due to this small range, the signals measured need to be amplified for better to be protection[11].

Typical biopotential amplifiers have high input impedance and are designed for safety first.

The most biopotential amplifiers are differential.They are used to make sure that noise from the inputs are not amplified thus yielding a higher integrity signal. The combinations of differential amplifiers are used to construct what is called an instrumentation amplifier[11].

Instrument amplifier is the most usable processing amplifier for precision amplification, it is used for large value of noise.Typical instrumentation amplifier schematic is shown in Figure(2.4).
There are two stages for the instrumentation amplifier that help make it meet the characteristics of an ideal biopotential amplifier.The first stage is the input stage of the amplifier followed by the gain stage. show figure (2.5). The input stage supplies no common mode gain thus eliminating common mode noise. It has high input impedance, it buffers gain stage, and the outputs of this stage are the inputs of gain stage. The gain stage is differential, low input impedance.Overall the amplifier amplifies only the differential component, it high common mode rejection ratio, and it high input impedance suitable for biopotential electrodes with high output impedance . the total differential gain is $Gd = (2R2 + R1)/ R1 (R4/R3)$.[11] The E-health sheild is complish this step inside it.

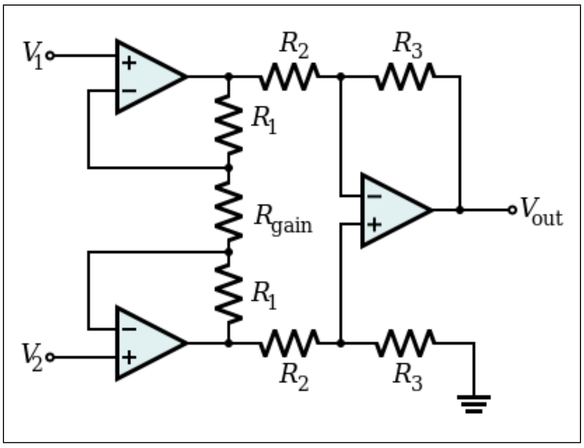

Figure 2.4: Typical instrumentation amplifier schematic.[11]

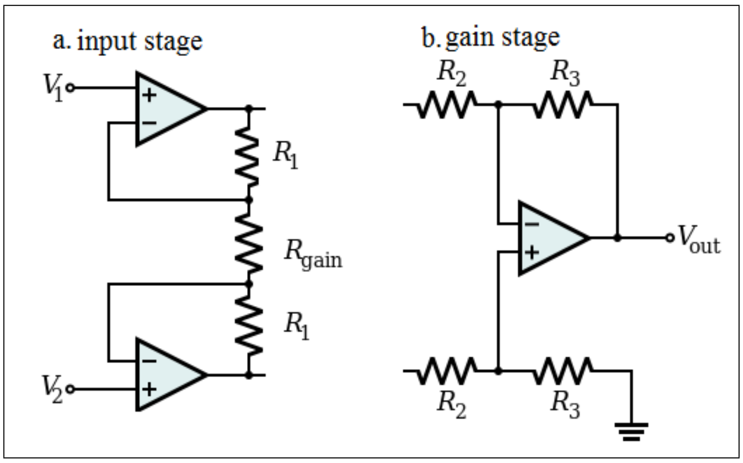

Figure 2.5: Input and gain stages of instrumentation amplifier.[11]

2.2.5 Processing for ECG signal

2.2.5.1 Feature extraction

There are many feature expert found that identify one person from another, we using amplitude feature as basic one.[12]:

- **Amplitude features.**

  The various amplitude features that can be extracted from an ECG signal are shown in Figure (2.6) The features can be selected that gives the difference of amplitude of two peaks, or a peak and a valley, or two valleys.

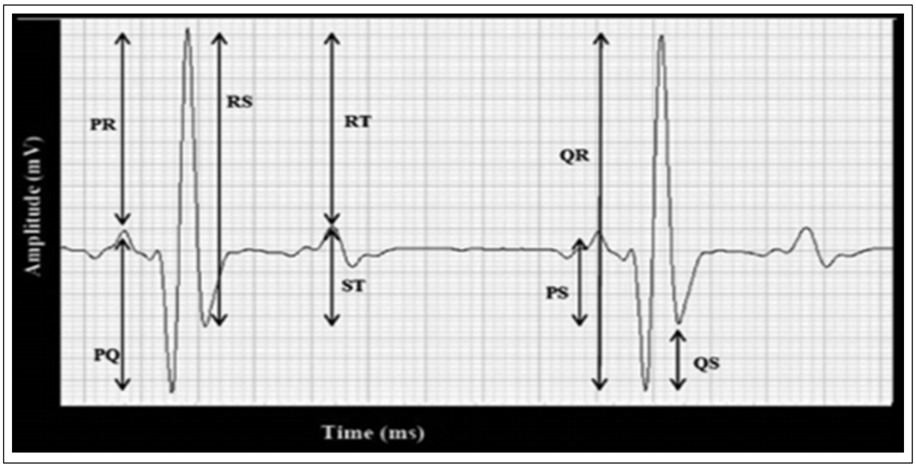

Figure 2.6: Amplitude features.[12]

- **Angle features**

The angle between PQR, QRS, and RST point of the ECG signal can be used for the authentication purpose. The Figure (2.7) shows the various angle features that can be extracted from the ECG signal[12].

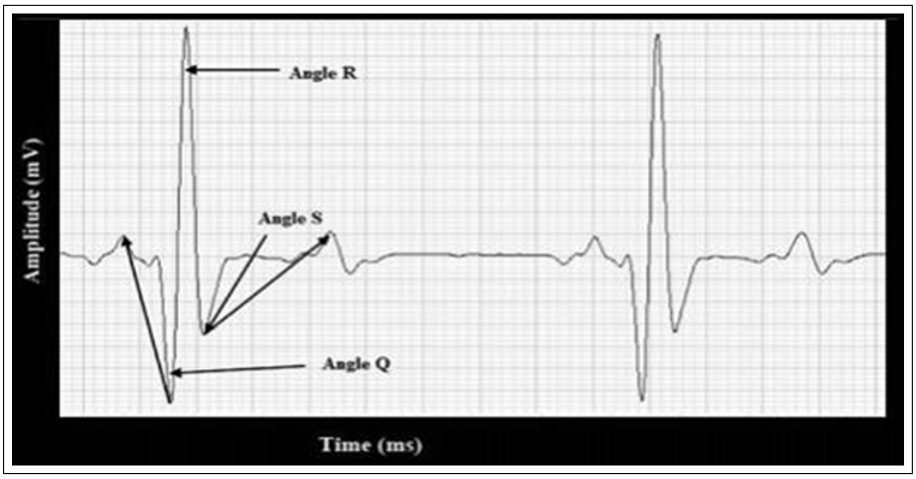

Figure 2.7: Angle feature.[12]

- **R-R interval**

R-R interval is the time difference of two R peak in the ECG signal. By detecting the occurrence of two consecutive peaks in the ECG signal RR interval can be measured as shown in Figure (2.8)[12].

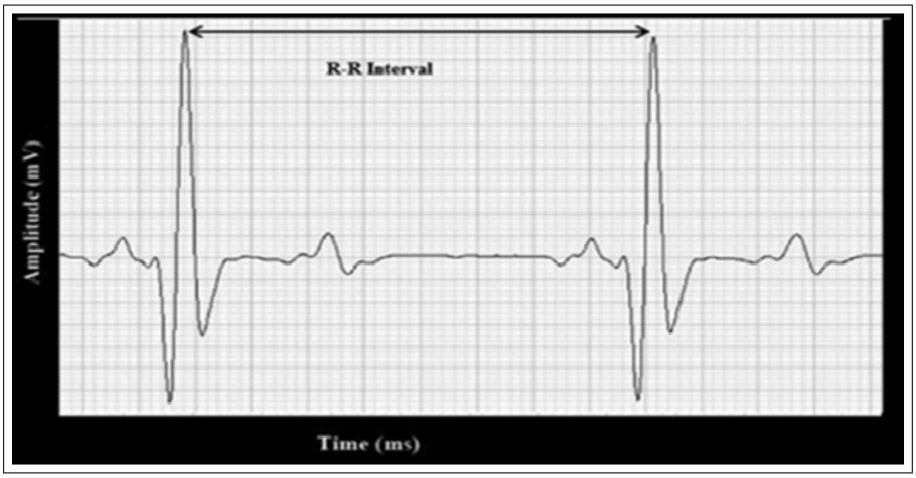

Figure 2.8: R-R interval.[12]

- **Interval features**

Time differences between various peaks,valleys,and the duration of peaks of a single ECG signal can also be measure as shown in Figure(2.9),and used for the authentication work[12].

2.2.5.2 Segmentation

The segmentation is one of the most important stage on the ECG signal process, because the analysis of the pattern that compose the ECG signal is the starting point for compression tasks, heart rat variability studies and beats classification on grouping .
Automatic segmentation of an electrocardiagram (ECG) using minimum of heuristic a priors information is an important problem in many research application areas.The various segment of an ECG have different physiological meaning and the presence, timing, and duration of each of these segments have diagnostic and biophysical importance the problem is made considerable more difficult, because the shape of ECG is quite variable.

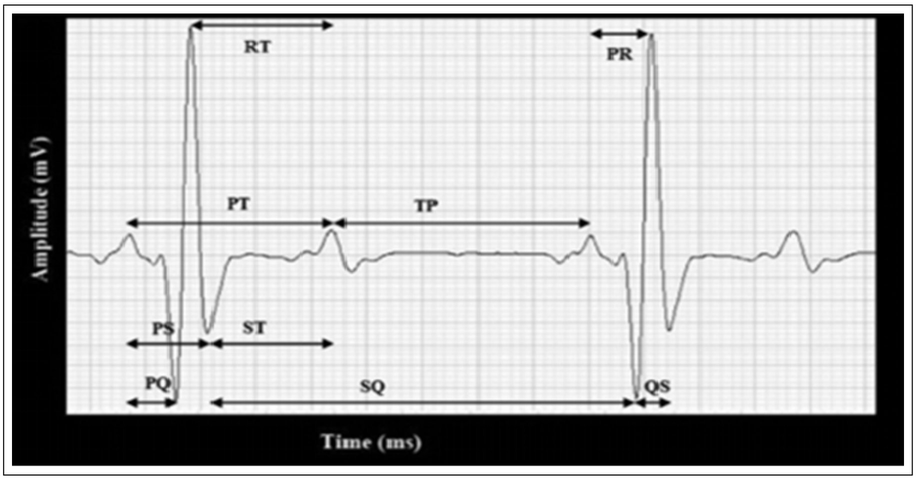

Figure 2.9: Interval feature of ECG.[12]

This variability depends on variety of factors such as the location of the electrode and the position of subjects body[13].

Electrocardiogram are traditionally divided into four main electrical events, each reflecting the electrical activity associated with particular phase of the cardiac cycle, these four events are named the P wave, QRS complex, ST segment and the T wave, and are illustrated for atypical ECG by the each segment represent specific physiological phase of the cardiac cycle, because of the close tie between the segment of the ECG signal and the underlying physiological states there has been considerable interest in the development of signal processing techniques to automatically perform this segmentation.See figure (2.10)[13].

RR Interval

The interval between an R wave and the next R wave this interval inverse the heart rat and the duration of it is 0.6 to 1.2s[13].

PR Interval

The PR interval is measured from the beginning of the QRS, this interval reflect the time the electrical impulse takes to interval from sinus node through the AV node and entering the ventricles[13].

ST Interval

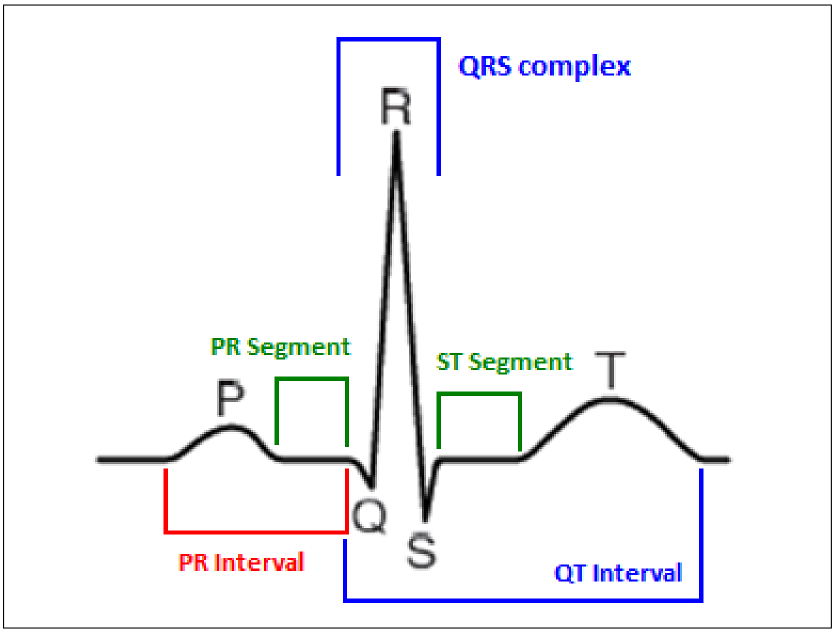

Figure 2.10: ECG segments and intervals[12].

The ST interval is measured from J point to the end of the T wave.
J point :The point at which the QRS complex finishes and the ST segment begins. It is used to measure the degree of ST elevation or depression present.[13].

QT Interval

The QT interval starts at the beginning of the QRS complex and finishes at the end of the T wave.It represents the time taken for the ventricles to depolarise and then repolarise (repolarization is when a cell membrane's charge returns to negative after depolarization.This is caused by positive potassium ions moving out of the cell.)[13].

ST segment

The ST segment starts at the end of the S wave and finishes at the start of the T wave.It represents ventricular repolarisation[13].

TP segment

Is between the end of the T wave and the beginning of the next P wave, it is the true is electric interval in the electrocardiogram.

PQ segment

PQ segment is a period of atria contraction.The depolarization is delayed in AV node[13].

2.2.5.3 Classification

The ECG signal indicates the electrical activity of the heart. Variations in the features of the ECG signal from a predefined pattern have been used routinely to identification person.Because of the difficulty to interpret these variations manually, a computer classification algorithm system can help in monitoring the cardiac ECG wave.Because of the nonlinear and no stationary nature of the ECG signal[14].

Since difference square is basically a pattern matching technique based on non linear input-output mapping, it can be effectively used for detecting morphological changes in non-linear signals such as the ECG signal. The issue of selecting an optimal set of relevant features plays an important role in pattern classification. To meet higher accuracy in pattern classification.[15]. Although different methods can be used to extract features from the same raw data, the integration of a feature extractor and a pattern classifier is essentially important.

2.2.5.4 K-Means clustering to QRS detection

The QRS complex detection is an important part of the ECG signal processing system. This section presents Fuzzy K-Means algorithm for detection of QRS complex in ECG signal , described how the proposed algorithm can be applied for the detection of QRS complex .

The algorithm is as follow

1. A raw digital ECG signal is acquired.
2. A raw ECG signal is often contaminated by disturbances such as power line interference and base line wander. There filter hardware circuit to remove it.
3. The gradient at every sampling instant is calculated to enhance the signal in the region of QRS-complex. The various slopes obtained at different sampling instant are divided in five clusters. Data centers

are randomly assigned to the clusters resulting in clusters that have roughly the same number of data centers.

For each data centers (peaks in ECG signal)

1. Calculate the distance from the data centers to each cluster.

2. If the data centers are closest to its own cluster, leave it where it is. If the data centers are not closest to its own cluster, move it into the closest cluster.

3. Repeat the above step until a complete pass through all the data centers results in no data centers moving from one cluster to another. At this center the clusters are stable and the clustering process ends.

Advantages to Using this Technique

1. With a large number of variables, K-Means may be computationally faster than hierarchical clustering (if K is small).

2. K-Means may produce tighter clusters than hierarchical clustering, especially if the clusters are globular.

Disadvantages to Using this Technique

1. Difficulty in comparing quality of the clusters produced (e.g. for different initial partitions or values of K affect outcome).

2. Fixed number of clusters can make it difficult to predict what K should be.

2.2.5.5 Square difference

The purpose of a measure of similarity is to compare two vectors, one vector(x) contain amplitude feature for real user and other contain amplitude feature for yet user(y), and compute a vector number which evaluates their similarity. We use Euclidean distance law, because it is reportedly faster than most other means of determining correlation .and it compares the relationship between actual ratings. This means that the Euclidean distance is a fair measure of how similar ratings are for specific preferences or items. Although there number of disadvantages:

1. Where there is a high noise-to-signal ratio and negative spikes, any correlation is difficult to establish. The Euclidean distance method also suffers in such cases.

2. Euclidean distance measures the correlation between quantitative, continuous variables. It is not suitable for ordinal data, where preferences are listed according to rank instead of according to actual values.

3. It can't determine the correlation between user profiles that have similar trends in tastes, but different ratings for some of the same items. A method like the Pearson correlation would give an indication of how similar a set of preferences are, regardless of fluctuations in individual ratings.

2.2.5.6 Euclidean distance

The basis of many measures of similarity and dissimilarity is Euclidean distance. The distance between vectors X and Y is defined as figure(2.11):

$$d(x,y) = \sqrt{\sum_{i}^{n} (x_i - y_i)^2}$$

Figure 2.11: Euclidean distance

In other words, Euclidean distance is the square root of the sum of squared differences between corresponding elements of the two vectors. Note that the formula treats the values of X and Y seriously: no adjustment is made for differences in scale. Euclidean distance is only appropriate for data measured on the same scale. A complete overlap (two vectors forming a single vector) should give me a value of 1, the greater the distance, between the vectors and the less similar the overall trend, the closer the value should go to 0.

2.3 Literature review

This section shows some of the literature review related to our project.

2.3.1 ECG biometrics: principles and applications

Electrocardiagram(ECG) signals that have several properties that can greatly complement the existing, and more established biometric modalities. Some of the most prominent properties are the fact that the signals can be continuously acquired using minimally intrusive setups, are not prone to produce latent patterns, and provide intrinsic liveliness detection, opening new opportunities within the area of biometric systems development.The potential impact of this technique extends to a broad variety of application domains,

ranging from the entertainment industry, to digital transactions.This paper present a framework for ECG biometrics, with focus on some of the latest developments and future trends in the field, covering multiple aspects of the problem with the aim of a real world deployment.The results so far, further reinforce the feasibility and interest of the method in a multibiometrics approach.
The unique properties of ECG signals, are particularly interesting in a multibiometrics approach, either as a security enhancement layer in hard biometrics systems, or as a standalone soft biometrics for low security and low user throughput applications.More importantly, as it can be continuously measured, it enables a new class of applications benefitting from the continuous biometric perspective.experimental results have been performed, which further reinforce the interest of the ECG based methods both in an identification and authentication approach[16].

2.3.2 Evaluation of electrocardiogram for biometric Authentication

This paper has evaluated the feasibility of ECG as a biometric for individual authentication and proposed a method for ECG enabled biometric authentication system. Unlike conventional biometrics that are neither secrest nor robust enough against calcification, ECG is in hearted to an individual which is highly secure and impossible to be forged.Most importantly, ECG has an inherent real time feature of vitality signs which ensures that an ECG cannot be acquired unless the person is not live or it can't be acquired unless the person to be authenticated is not present at the authentication desk.Therefore, it is robust enough against the falsified credentials to be enrolled in the system. We have shown that ECG has potential to provide an excellent source of supplementary information in a multi biometric system.The fusion of ECG with the face biometric and with the fingerprint biometric has shown a significant improvement in authentication performance of both of the fused systems.In addition, the research concerns of ECG enabled biometric authentication system across wide range of conditions The laboratory demonstration of the biometric use of ECG has shown great promise, but the fruitful directions for further research include the following[17]:

1. The ECG enabled biometric system must perform the authentication task across wide range of conditions over a larger population including the data acquired at larger time intervals.

2. It is important to discover that up to what ex-tent an ECG varies under

different anxiety levels.An investigation of robustness to the subjects of different.

2.3.3 Identification and delineation of QRS complexes in electrocardiogram using fuzzy c-means algorithms

In this paper , many systems have already been implemented to perform signal processing task such as 12-lead ECG analysis. All these applications require an accurate detection of QRS complex of ECG. Thus QRS complex detection is an important part of many ECG signal processing system. This paper presents application of Fuzzy C-Means algorithm (FCM) for detection of QRS complex in ECG signal. The performance of the algorithm is validated using original 12-lead ECG recording from the standard ECG data base. Significant detection rate is achieved. The onset and offset of the QRS complexes are found to be within tolerance limit given by CSE library.

2.4 Summary

In this chapter we talked about theoretical background of the system, also the literature related to the project main idea ,all of this described using different notation and models.

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Chapter 3

Project management plan

3.1 Overview

In this chapter we talk about project management plan, so we discuses some of the topics like Task set, Risks, project resource, total estimation cost and time estimation, project methodology, option, analysis of each option, project components such that hardware component, software component, other component.

3.2 Project management plan

This section talkes about task set, risks, project resourse, total estimated cost and time estimated .

3.2.1 Task set

The project activities depend on each other, so the task durations and dependencies are shown in Table [3.1] part one and part two.

3.2.2 Risks

There are some possible risks that may occur in our project in both hardware and software .In this section will briefly describe those risks and show their management. The Table [3.2] lists the types of riskS which may impact the project development process, showing the risk and its type Technology, people, organizational, tools, requirements, and estimation .

- Table [3.3] shows the probability and effect of each risk .
- Table [3.4] shows the strategies that address each risk.

3.2.3 Project Resource and estimated cost

In this section we will preview the system cost estimation in term of system Hardware, system software, and human resources.

3.2.3.1 Hardware resources

The project estimated costs were calculated and found to be around 450. Table [3.5] provides a detailed list of the components needed for the project.

3.2.3.2 Software resources

The software resources are summarized in Table[3.6].

3.2.3.3 Human resources

The human resources are summarized in Table[3.7].

3.2.3.4 Total cost

Total costs are summarized in Table[3.8].

3.2.3.5 Time estimated

1. Figure(3.1)show time estimated for the first semister.

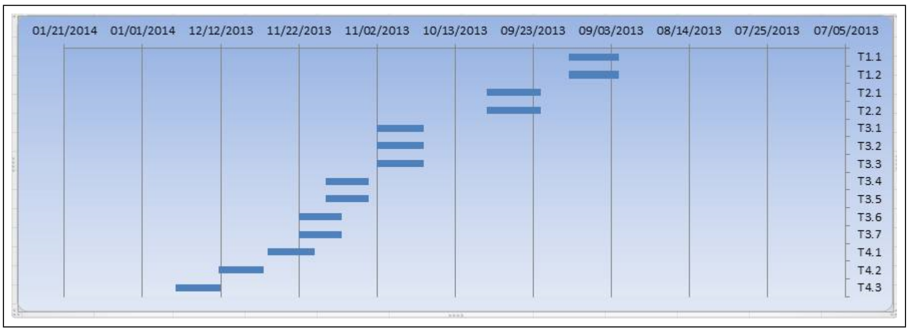

Figure 3.1: Time estimated - part one

2. Figure(3.2)show time estimated for the second semister.

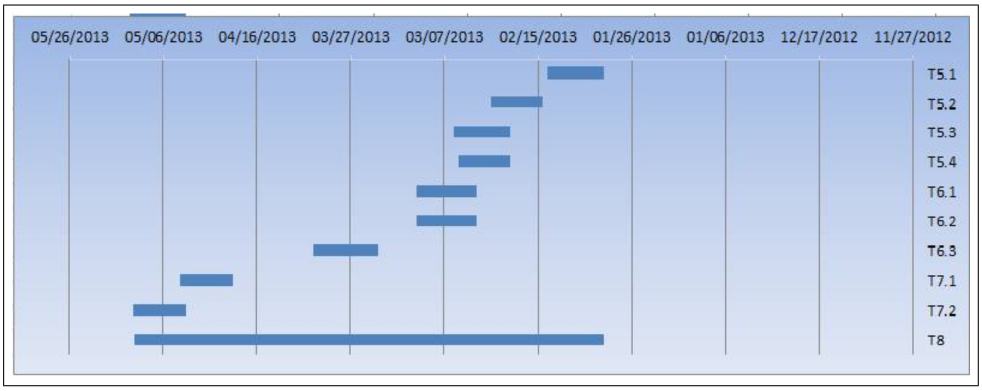

Figure 3.2: Time estimated - part two

3.2.4 Project methodology

There are many issues that must consider in order to build a functional successful and reliable portable security system.That issue involves choice of major component.There are many alternative option for choosing each component and this section talks about each available option.

3.2.4.1 Microcontroller

A microcontroller is a small computer on a single integrated circuit consisting of a relatively simple CPU combined with support functions such as a crystal oscillator, timers, watchdog timer, serial and analog I/O etc. Program memory in the form of EEPROM (Electrically Erasable Programmable Read Only Memory) or ROM (Read Only Memory) is also often included on chip, as well as a typically small amount of RAM (Random Access Memory).Microcontrollers are used in automatically controlled products and devices[18].

1. Option one : Arduino .

   Arduino is a single board microcontroller, intended to make the application of interactive objects or environments more accessible.[1] The hardware consists of an open-source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. Current models feature a USB interface, 6 analog input pins, as well as 14 digital I/O pins which allows the user to attach various extension boards.

   The Arduino platform was designed to provide an inexpensive and easy way for hobbyists, students and professionals to create devices that interact with their environment using sensors and actuators. It comes with a simple integrated development environment that runs on regular personal computers and allows users to write programs for Arduino using C or C++.[19].

We use two type of arduino :

(1) Arduino Board Mega as figure(3.3).

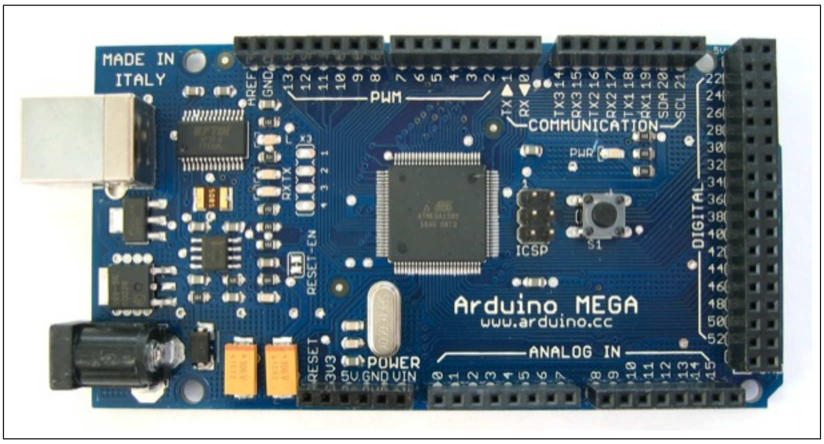

Figure 3.3: Arduino Mega.

(1) **Overview**

The Arduino Mega is a microcontroller board based on the ATmega1280 . It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila.

(2) **Characteristics**

The Characteristics of the arduino board Mega as figure(3.4).

(3) **Power**

Microcontroller	ATmega1280
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	128 KB of which 4 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

Figure 3.4: Characteristics of the arduino board Mega.

The Arduino Mega can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The power pins are as follows:

- VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V. The regulated power supply used to power the microcontroller and other components on the board. This can

come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.

- 3V3. A 3.3 volt supply generated by the on-board FTDI chip. Maximum current draw is 50 mA. GND. Ground pins.

(4) **Memory**

The ATmega1280 has 128 KB of flash memory for storing code (of which 4 KB is used for the bootloader), 8 KB of SRAM and 4 KB of EEPROM (which can be read and written with the EEPROM library).

(2) Arduino Board Due as figure(3.5).

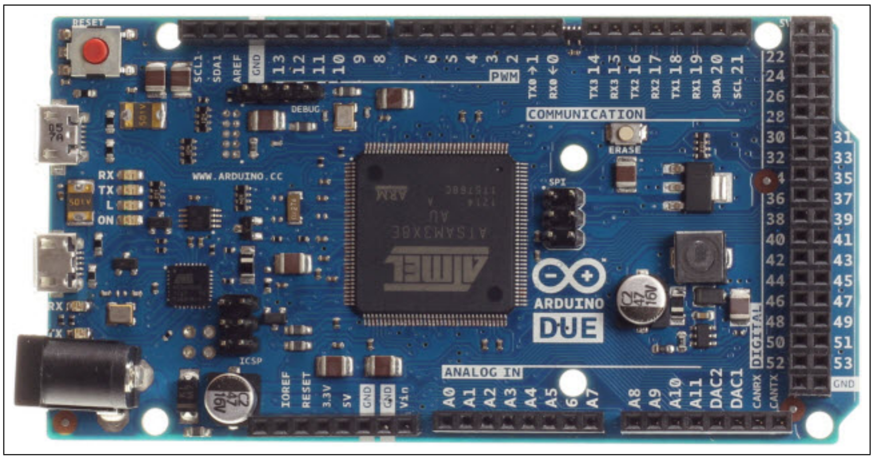

Figure 3.5: Arduino Due.

(1) **Overview**

The Arduino Due is a microcontroller board based on the Atmel SAM3X8E ARM Cortex-M3 CPU. It is the first Arduino board based on a 32-bit ARM core microcontroller. It has 54 digital input/output pins (of which 12 can be used as PWM outputs), 12 analog inputs, 4 UARTs (hardware serial ports), a 84 MHz clock, an USB OTG capable connection, 2 DAC (digital to analog), 2 TWI, a power jack, an SPI header, a JTAG header, a reset button and an erase button. **Warning: Unlike other Arduino boards, the Arduino Due board runs at 3.3V. The maximum voltage that the**

I/O pins can tolerate is 3.3V. Providing higher voltages, like 5V to an I/O pin could damage the board. The board contains everything needed to support the microcontroller; simply connect it to a computer with a micro-USB cable or power it with a AC-to-DC adapter or battery to get started. The Due is compatible with all Arduino shieldscthat work at 3.3V . T

(2) **Characteristics**

The Characteristics of the arduino board Mega as figure(3.6).

Microcontroller	AT91SAM3X8E
Operating Voltage	3.3V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-16V
Digital I/O Pins	54 (of which 12 provide PWM output)
Analog Input Pins	12
Analog Outputs Pins	2 (DAC)
Total DC Output Current on all I/O lines	130 mA
DC Current for 3.3V Pin	800 mA
DC Current for 5V Pin	800 mA
Flash Memory	512 KB all available for the user applications
SRAM	96 KB (two banks: 64KB and 32KB)
Clock Speed	84 MHz

Figure 3.6: Characteristics of the arduino board Due.

(3) **Power**

The Arduino Due can be powered via the USB connector or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of

6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The power pins are as follows:

(1) VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or if supplying voltage via the power jack, access it through this pin.
(2) 5V. This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.
(3) 3.3V. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 800 mA. This regulator also provides the power supply to the SAM3X microcontroller.
(4) GND. Ground pins.
(5) IOREF. This pin on the Arduino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs for working with the 5V or 3.3V.

(4) **Memory**

The SAM3X has 512 KB (2 blocks of 256 KB) of flash memory for storing code. The bootloader is preburned in factory from Atmel and is stored in a dedicated ROM memory. The available SRAM is 96 KB in two contiguous bank of 64 KB and 32 KB. All the available memory (Flash, RAM and ROM) can be accessed directly as a flat addressing space. It is possible to erase the Flash memory of the SAM3X with the onboard erase button. This will remove the currently loaded sketch from the MCU. To erase, press and hold the Erase button for a few seconds while the board is powered.

2. Option two : DSPIC Microcontroller.

   TA Digital signal microcontroller (DSC) is a single-chip, embedded controller that seamlessly integrates the control attributes of a Microcontroller (MCU) with the computation and throughput capabilities of a Digital Signal Processor (DSP) in a single core. Microchip's DSPIC offers everything would expect from a powerful . 16-bit MCU: fast, sophisticated and flexible interrupt handling; a wide array of digital and analog peripheral functions; power management; flexible clocking options; power-on-reset; brown-out protection; watchdog timer; code security. full-speed real-time emulation; and full-speed in-circuit debug solutions. By skillfully adding DSP capability to a high-performance 16-bit MCU, Microchip's dsPIC30F and dsPIC33F families of DSCs achieve the best of both worlds and mark the beginning of a new era in embedded control.[20].

3.2.4.2 Sensor

A sensor is a device, which responds to an input quantity by generating a functionally related output usually in the form of an electrical or optical signal.A sensor's sensitivity indicates how much the sensor's output changes when the measured quantity changes [21].

1. Option one : E-health Sensor platform as figure(3.7). The e-Health

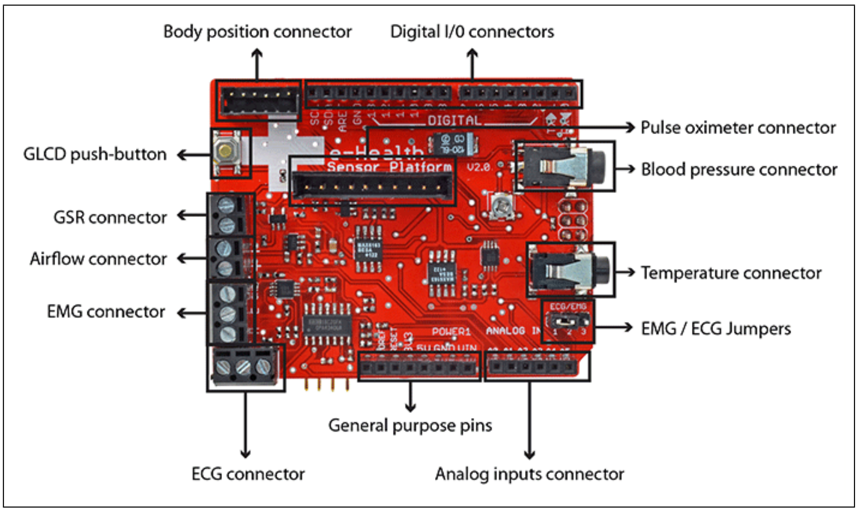

Figure 3.7: E-health Sensor platform.

   Sensor Shield allows Arduino users to perform biometric and medical applications where body monitoring is needed by using 10 different sensors: pulse, oxygen in blood (SPO2), airflow (breathing), body temperature, electrocardiogram (ECG), glucometer, galvanic skin response (GSR - sweating), blood pressure (sphygmomanometer), patient position (accelerometer) and muscle/eletromyography sensor (EMG).[22]. in our project we need to use only the ECG sensor and connect ECG electrodes to it as figure(3.8).

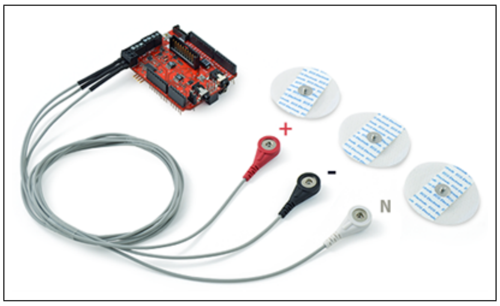

Figure 3.8: ECG electrodes with E-Health sheild.

2. Option two : PS25201 ECG sensor.

   The PS25251 is an ultra high impedance solid state ECG (electrocardiograph) sensor. It can be used as a dry contact ECG sensor without the need for potentially dangerous low impedance circuits across the heart. The resolution available is as good as or better than conventional wet electrodes.[22] The device uses active feedback techniques to both lower the effective input capacitance of the sensing element and boost the input resistance.These techniques are used to realize a sensor with a frequency response suitable for both diagnostic and monitoring ECG application.

3.2.5 Project components

3.2.5.1 Hardware components

This section is show hardware components of our project.Figure (6.1)show block diagram for all hardware component of our project.

1. **Bluetooth**

   Bluetooth is a wireless technology standard for exchanging data over short distances . The portable device uses the BLE to reliably communicate with the c charp application .

2. **ECG Electrodes with E-health sensor platform**

   Electrocardiogram (ECG) and E-health sensor platform measure heart muscle, over time by measuring electric potentials of heart on the surface of body .

3. **Battery**

   It used to provides portable device of require power, we can charge This battery by USB like mobile.

4. **LED**

   After LED is illuminate ,portable device authenticated the user and it turn on.

5. **Arduino Mega**

   It used to read ECG signal from E-health sensor platform because this platform work only Arduino uno and arduino mega .

6. **Arduino Due**

   It Used to take ECG signal from Arduino Mega and then make processing on ECG signal and comparator operation between the stored ECG waveform and the ECG that measure when portable device start work, and it used to convert analog signal to digital signal.

3.2.5.2 Software components

1. **Arduino code** It used to implement arduino Mega , aurduino Due and to write code of the all project.

2. **Matlab code** Matlab code is used in test of the software .

3. **C charp** It used to implement application that connect to bluetooth and receive password from it .

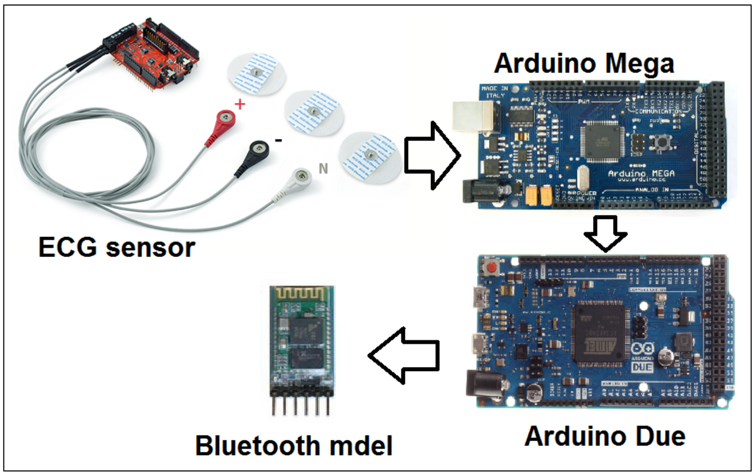

Figure 3.9: Block diagram of hardware component

3.2.5.3 Other components

We need other component in our project , to build the portable device like metal plate to collect all component on it .

3.2.6 Summary

This chapter was talked about project management plan , that included Task set, risks, project resource, total estimation cost and time estimation, project methodology, option, analysis of each option, project components such that hardware component, software component, other component .

Task No.	Task Name	Time (weeks)	Parallelism	Dependency
T1	Selecting the project	3		
T1.1	Searching in internet and library for the idea of project	3	T1.2	
T1.2	Ask advisor for help to select idea	3	T1.1	
T2	Collecting information, literature review and related theory	4		T1
T2.1	Study Literature review and theory	4	T2.2	
T2.2	Summery and document Literature review and theory	4	T2.1	
T3	Project analysis	4		T2
T3.1	Time scheduling	2	T3.2 , T3.3	
T3.2	Determine the HW and SW needed	2	T3.1 , T3.3	
T3.3	Determine the cost of the project	2	T3.1 , T3.2	
T3.4	Risk management	1	T3.5	
T3.5	Project methodology	1	T3.4	
T3.6	HW components analysis	1	T3.7	
T3.7	SW components analysis	1	T3.6	
T4	Project design	5		T3
T4.1	Design block diagram	2		
T4.2	Design the software schematic diagram	1.5		
T4.3	Design the hardware schematic diagram	1.5		

Table 3.1: Tasks Plan- part one

Task No.	Task Name	Time (weeks)	Parallelism	Dependency
T5	Hardware design and implementation	6		
T5.1	System specification design	2		
T5.2	Collect the HW components	1		
T5.3	Implement the sensors and Microcontroller	2		T5.1 ,T5.2
T5.4	Connect the micro-controllers with peripherals	1		T5.3
T6	Software implementation and execution	7		T3,T4,T5
T6.1	Collect the samples for training and testing phases	3	T6.2	
T6.2	Perform the train phase using PC ,testing accuracy	3	T6.1	
T6.3	Write the software program	4		
T7	Test the system	3		
T7.1	Correct error if exist in hw or SW	1.5		
T7.2	Re- execution to sure it run correct	1.5		
T8	Writing documentation	29	T1 ,T2,T3,T4 ,T5,T6,T7,T8	T1,T2,T3,T4 ,T5,T6,T7,T8

Table 3.2: Tasks Plan- part two

Type of Risk	Possible Risks	
Technology	R1	Hardware which is essential for the project may not be delivered on schedule.
	R2	Malfunction of hardware parts (PC, Microcontroller ,and Sensors).
	R3	Undesirable and unexpected software error.
Requirements	R4	There may be changing the requirements than anticipated.
Estimations	R5	The required time developing the software and the hardwar is underestimated.
	R6	The size of the software and the hardware is underestimated.
	R7	The Budget is not sufficient.
Tools	R8	Code of the software is damaged or deleted suddenly.
Organizational	R9	Time of delivery of the project changed.
People	R10	Shortened in work of any group members for any reason.

Table 3.3: Risks Identification and Characterization

Risk ID	Risk	Probability	Effects
R1	Hardware which is essential for the project may not be delivere on schedule	Moderate	Catastrophic.
R2	Malfunction of hardware parts (PC, Microcontroller and Sensors)	LOW	Serious.
R3	Building the accurate classifier	Moderate	Serious.
R4	There may be a larger number of changes to the requirements than anticipated	Low	Tolerable.
R5	The time required developing the software and Hardware is underestimated	Low	Tolerable.
R6	The size of the software and Hardware is underestimated	Low	Tolerable.
R7	The Budget is not sufficient	Moderate	Catastrophic.
R8	Code of the software is damaged or deleted suddenly	Very low	Catastrophic.
R9	Time of delivery of the project changed	Very low	Tolerable.
R10	Shortened in work of any group members for any reason	Low	Tolerable.

Table 3.4: Risk Probability and Analysis.

Risk ID	Strategy
R1	Identify the needed hardware as fast as possible and order them.
R2	Continue the project development and simulate the network operation.
R3	Simplifying the needed machine learning algorithms and total required recognition tasks.
R4	Derive traceability information to assess requirements change impact, and maximize information hiding in the design.
R5	Understand almost the exact time needed in developing the software and hardware.
R6	Understand almost the exact size for the software and hardware.
R7	Determine the project's cost before starting the implementation and Borrow the needed money if this risk occure.
R8	Always save backup copies of the software (on flash, CDs, hard disks).
R9	Try to done the job to comply with the specific period.
R10	Reorganize team so that there is more overlap in the work.

Table 3.5: Risk Management Strategies

hardware component	Required number	cost ($)
Bluetooth JY MCU	1	60
Battery	1	5
E-health sheild	1	295
LED	1	1
ECG Electrodes	2	17
ECG Electrodes cable	2	75
Wire to connect project part	15	5
ECG circuit component (resistors,capacitors,filter 741,AD620 ,PCB Piece electronicr)	5	27
Microcontroller(arduino Due , Mega)	1	220
PC (Lenovo B590)	3	free
Total		700

Table 3.6: Hardware resources cost

Software component	Required number	cost ($)
Microsoft Visual Studi 2010	3	Free
Windows 7 Ultimate Edition	3	Free
Microsoft Office 2007 proffesional	3	Free
Microsoft Office Visio 2007	3	Free
Matlab 2010	3	Free
Arduino	3	Free
LATEX	1	Free
Total		Free

Table 3.7: Software resources cost

Humman resource	number	costs ($)
working team	3	free

Table 3.8: Human Resources

Resources	Costs($)
Hardware resources	700
Software resources	Free
Human resources	free
total	700

Table 3.9: Software resources cost

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Chapter 4

Software requirement specification

4.1 Overview

This chapter represents the requirement description of our project; it explains the requirement as scenarios using use-case diagram, class responsibilities collaborator, and class hierarchies and relationships.

4.2 Requirement description

This section explains the requirement of the system; represent it as scenarios, and using use-case diagram to show that .

4.2.1 Template for detailed description of use case

This section shows detailed description of all the use cases in project .

- Table [4.1] show activate the system use case .

Use-case	activate the system
Primary actor	User
Goal in context	To make system ready to work, so system can read the ECG signal user's when user's attach the system.
Preconditions	system has been attached to user's skin (put electrodes in his body).
Trigger	The user decides to set the system, i.e.,to close the electricalcircuit body (ECG circuit).
Scenario	1. Put electrodes on the body.2. Run the system
Exceptions	1. User put his elecrodes on the wrong place on his body.2. Electrical circuit body not closes.3. Sensor in the system is fault.

Table 4.1: Activate the system use-case.

- Table [4.2] show deactivate the system use case.

Use-case	dectivate the system
Primary actor	User
Goal in context	To stop working the system (make system off).
Preconditions	Put the system (portable device) far away from his body
Trigger	The user decides to reset the system.
Scenario	1. deposes/enrobe the system (portable device). 2. Put the system far away from his body.
Exceptions	System fault and continuous reading ECG signal.

Table 4.2: Dectivate the system use-case.

- Table [4.3] show closed ECG electrical circuit use case.

Use-case	Closed the electrical circuit of ECG.
Primary actor	Touch sensor.
Goal in context	Closed the electrical circuit of ECG.
Preconditions	User put electrodes on his body and then ECG electrical circuit closed.
Trigger	Closed the electrical circuit of ECG, so ECG sensor can begin read ECG signal.
Scenario	1. Attach to the user's body . 2. Sensing of user's skin consistence . 3. Closed the electrical circuit of heart.
Exceptions	1. Sensor in the system is fault. 2. System not activates. 3. System not works correctly.

Table 4.3: Closed the electrical circuit of ECG use-case.

- Table [4.4] show read ECG signal use case .

Use-case	Read ECG signal.
Primary actor	ECG sensor.
Goal in context	Read the ECG signal
Preconditions	System has been activated by user, closed the electrical circuit of ECG.
Trigger	Read ECG signal from user's body .
Scenario	1. Start working after close ECG electrical circuit. 2. Driven the form of ECG . 3: record ECG signal for the user.
Exceptions	1. Sensor in the system is fault. 2. There is no ECG signal for user (person died). 3. System not activates. 4. System not works correctly. 5. There is attenuation in ECG signal. 6. The person not the real one.

Table 4.4: Read ECG signal use-case.

• Table [4.5] show ECG signal as password of PC use case.

Use-case	ECG signal as password of personal computer.
Primary actor	System.
Goal in context	To make system ready to open personal computer by ECG signal stored as correct password in both the system and personal computer
Preconditions	System has been worked correctly, personal computer ready to attach to the system via wireless or Bluetooth.
Trigger	The user decides to open website
Scenario	1. Convert ECG signal into digital signal (password code). 2. Run wireless/Bluetooth device on it. 3. Send password code for personal computer via wireless/Bluetooth, to open it.
Exceptions	1. Wireless /Bluetooth are fault. 2. System is fault.

Table 4.5: ECG signal as password of personal computer use-case.

- Table [4.6] show received password code from the system use case.

Use-case	Received password code from the system
Primary actor	Personal computer.
Goal in context	To make personal computer ready to receive password code via wireless.
Preconditions	System has been sent password code; personal computer has an wireless on it and work correctly.
Trigger	The user decides to use personal computer
Scenario	1. Run as correct way, and ready to work. 2. Run wireless on it. 3. Search for available wireless device. 4. Ready to receive password code from system.
Exceptions	1. Wireless /Bluetooth is fault in system or in personal computer. 2. Personal computer is fault and unable to work. 3. System is fault.

Table 4.6: Received password code from the system use-case.

- figure(4.1) show Use case diagram for the Biometric identification system based on Electrocardiogram data.

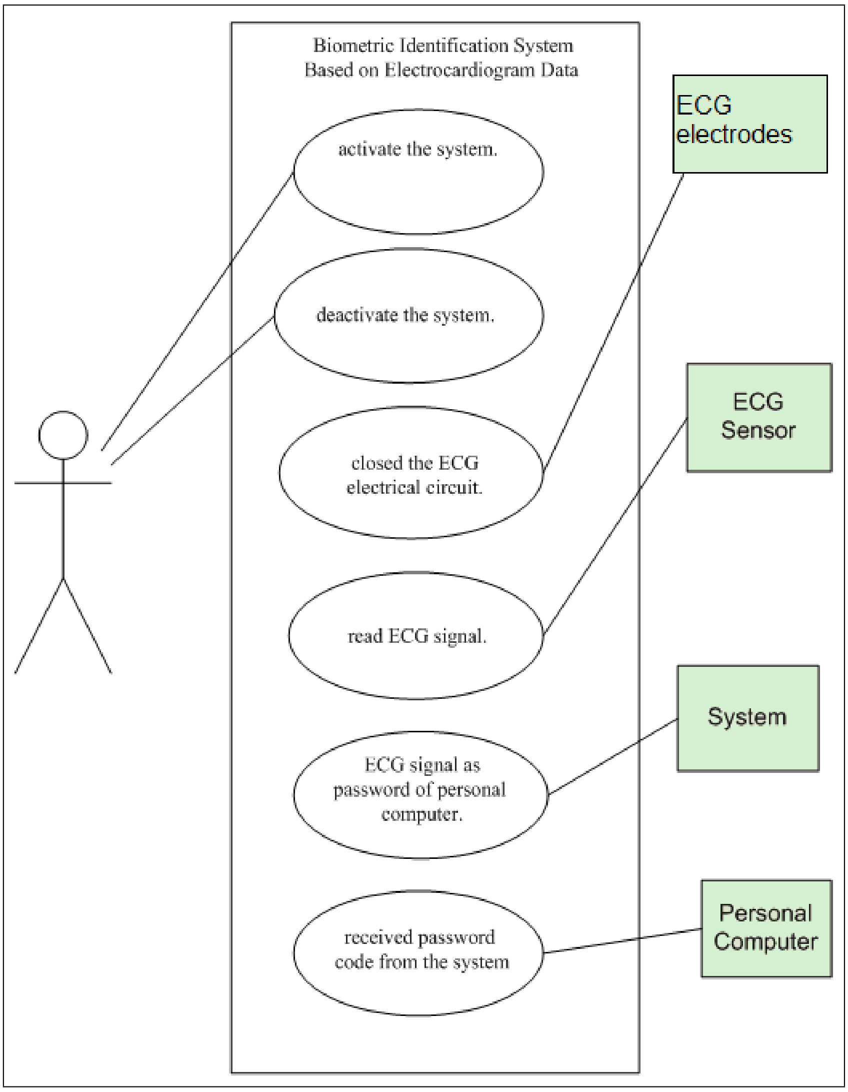

Figure 4.1: Use case diagram for Biometric identification system based on Electrocardiogram data.

4.2.2 Activities diagrams

This section shows activity diagram for each use case in project .

- figure(4.2) show activity diagram for activate system .

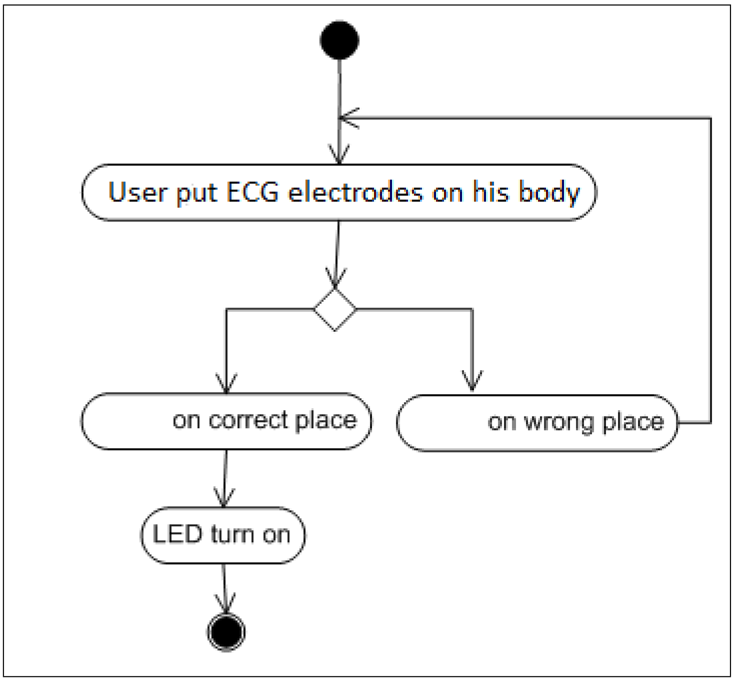

Figure 4.2: Activity diagram for activate system.

- figure(4.3) show activity diagram for deactivate system.

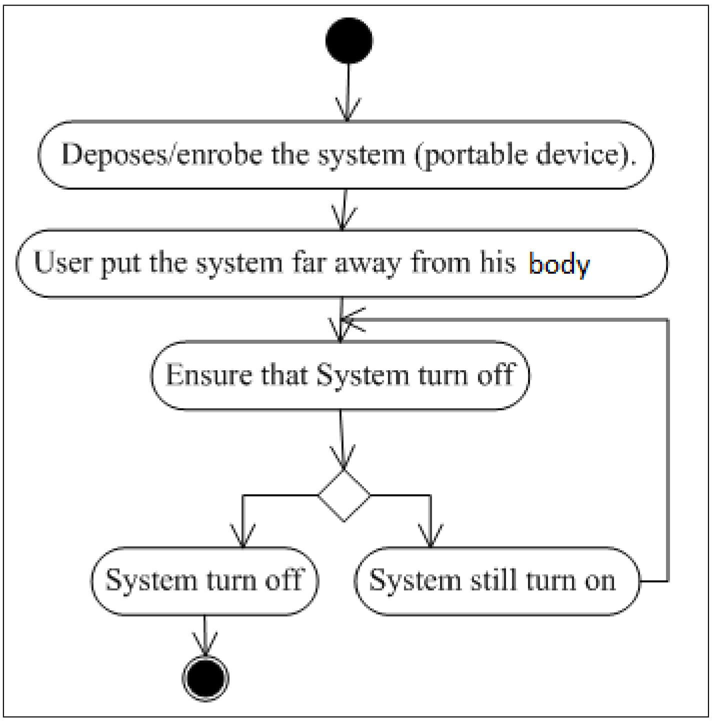

Figure 4.3: Activity diagram for deactivate system.

- figure(4.4) show activity diagram for closed ECG electrical circuit.

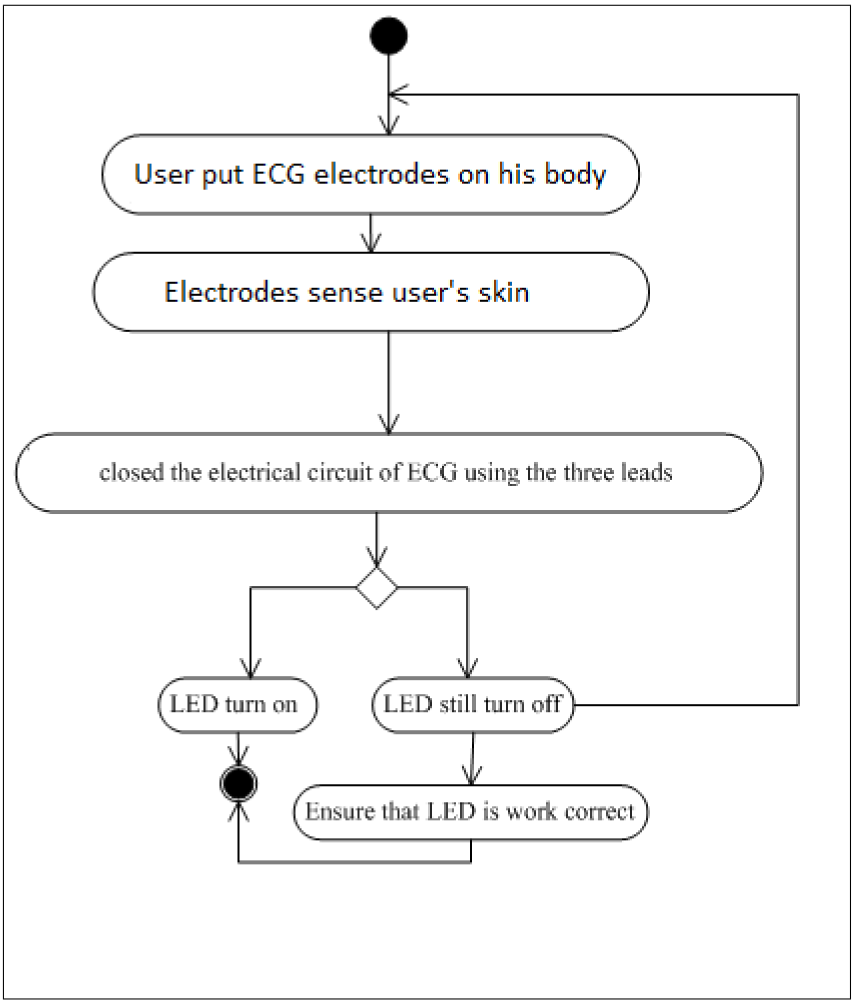

Figure 4.4: Activity diagram for closed ECG electrical circuit.

- figure(4.5) show activity diagram for read ECG signal.

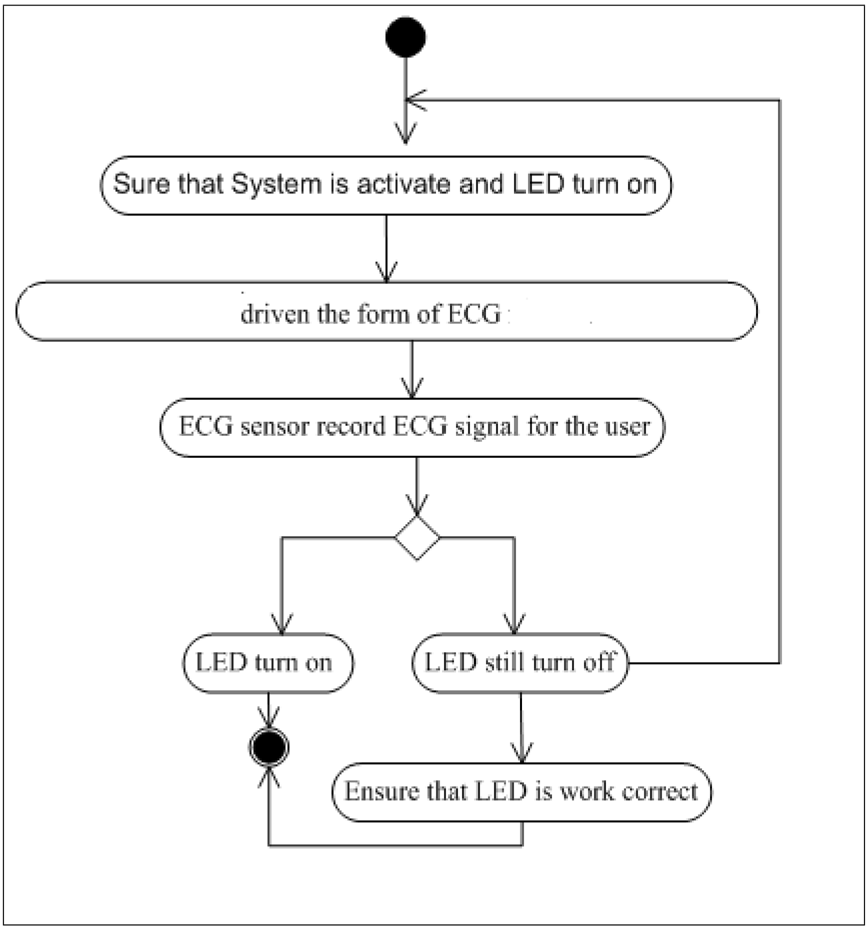

Figure 4.5: Activity diagram for read ECG signal.

- figure(4.6) show activity diagram for ECG signal as password of personal computer.

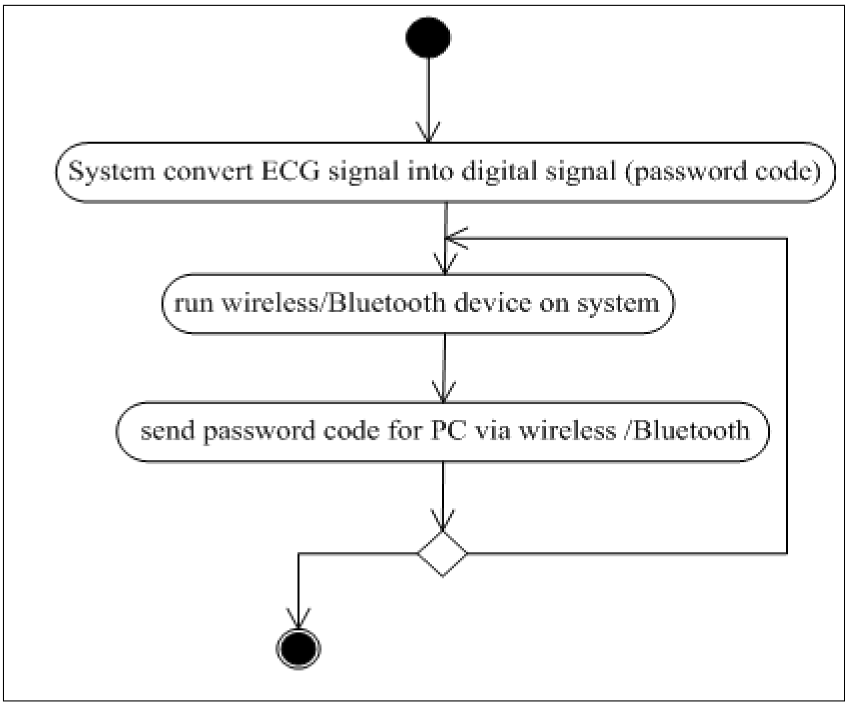

Figure 4.6: Activity diagram for ECG signal as password of personal computer.

- figure(4.7)show activity diagram for received password code from the system.

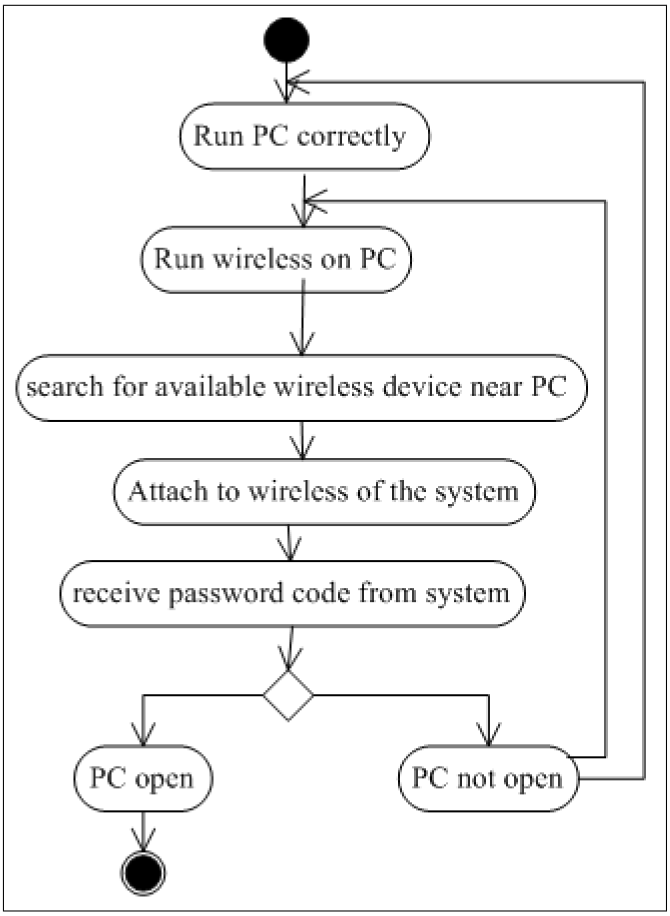

Figure 4.7: Activity diagram for received password code from the system.

4.2.3 State diagram

State diagram of the project represent the action that happen in the system.See figer(4.8).

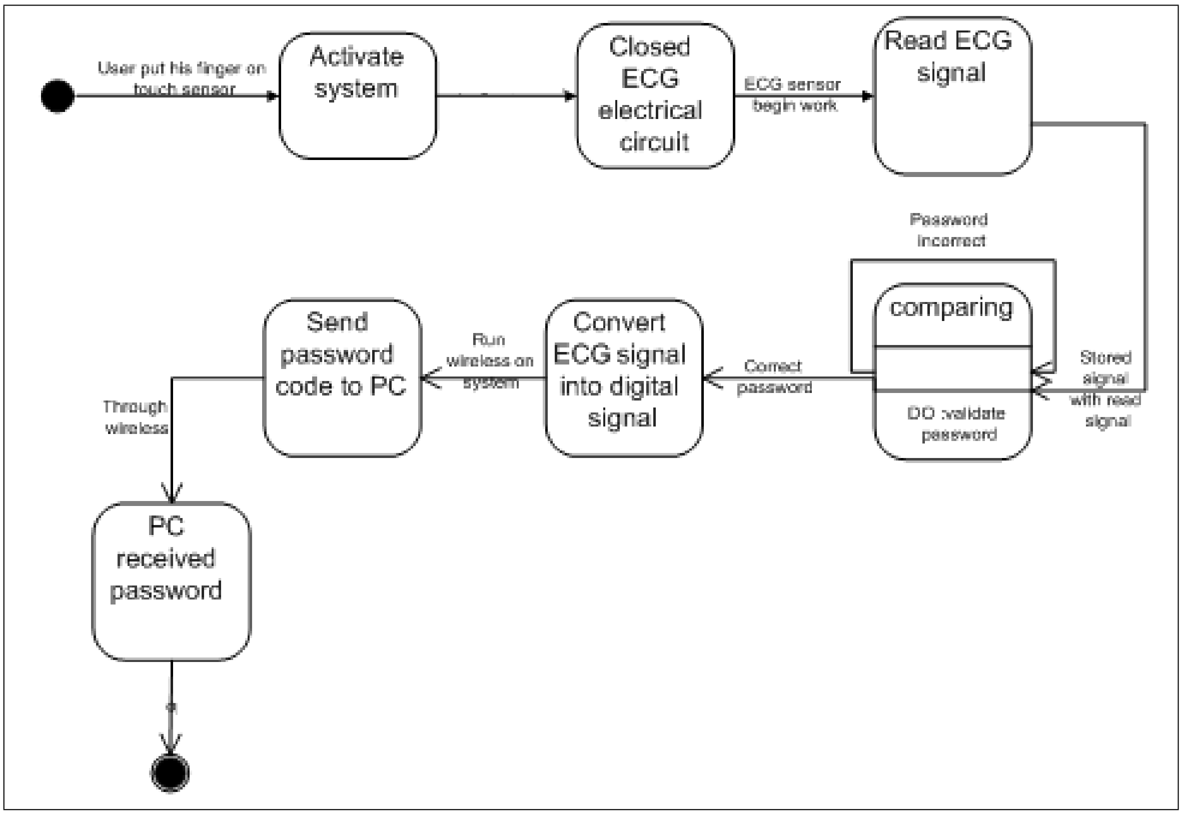

Figure 4.8: State diagram.

4.3 CRC (class responsibilities collaborator)

This section talked about the class responsibilities collaborator, the CRC provides a simple means for identifying and organizing the classes that are relevant to system requirements.

Class : Personal computer	
Responsibility	Collaborator
Receives password code( )	wireless
Attribute	
ID Name Memory speed	

Table 4.7: CRC model for personal computer class.

Class : User	
Responsibility	Collaborator
Activate system () deactivate system()	ECG electrodes
Attribute	
ID Name Memory speed	

Table 4.8: CRC model for user class.

Class : wireless	
Responsibility	Collaborator
Transfer signal through it ( )	PC
Attribute	
ID Name Type	

Table 4.9: CRC model for wireless class.

Class : Converter	
Responsibility	Collaborator
transfer ECG signal into digital signal ( )	ECG sensor
Attribute	
ID Name Type	

Table 4.10: CRC model for converter class.

Class : ECG sensor	
Responsibility	Collaborator
Read ECG sensor ( )	ECG electrodes
Attribute	
ID Name Type	

Table 4.11: CRC model for ECG sensor class.

Class : Touch sensor	
Responsibility	Collaborator
Sensing user's skin ( )	user
Attribute	
ID Name Type	

Table 4.12: CRC model for touch sensor(ECG electrodes) class.

4.4 class hierarchies and relationships

Class hierarchies and relationships , show the relation between all class in the system .show figer (4.9) .

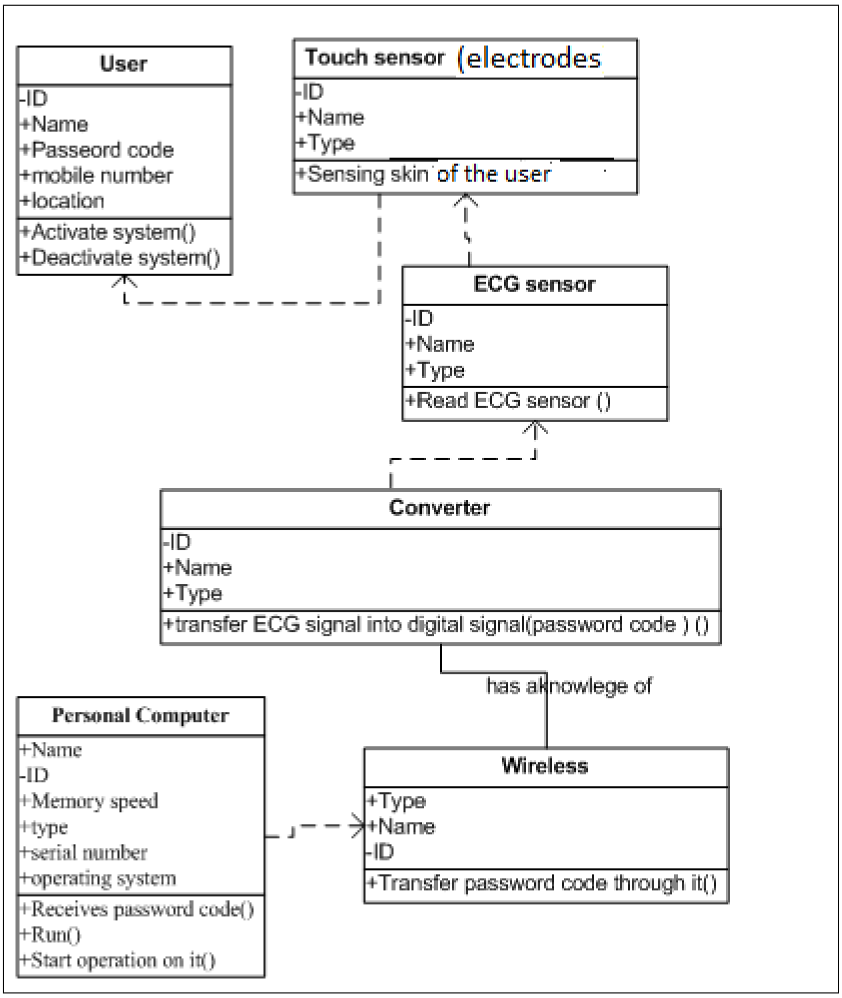

Figure 4.9: class hierarchies

4.5 Summary

This chapter is talked about the requirement description of our project; it explains the requirement as scenarios using use-case diagram, class responsibilities collaborator, and finally chapter represent class hierarchies and relationships.

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Chapter 5

System design

5.1 overview

This chapter talks about objects relational model for the software components, State behavioral modeling that include control flow, data flow and state flow , chapter show subsystem design so that it have a description of each subsystem's tasks and components , software and hardware , also chapter talk about class and object design , interface design for both software and hardware components.

5.1.1 System block diagram

This subsection is talk about system block diagram, it show in detailed both software and hardware components.See figure(5.1).

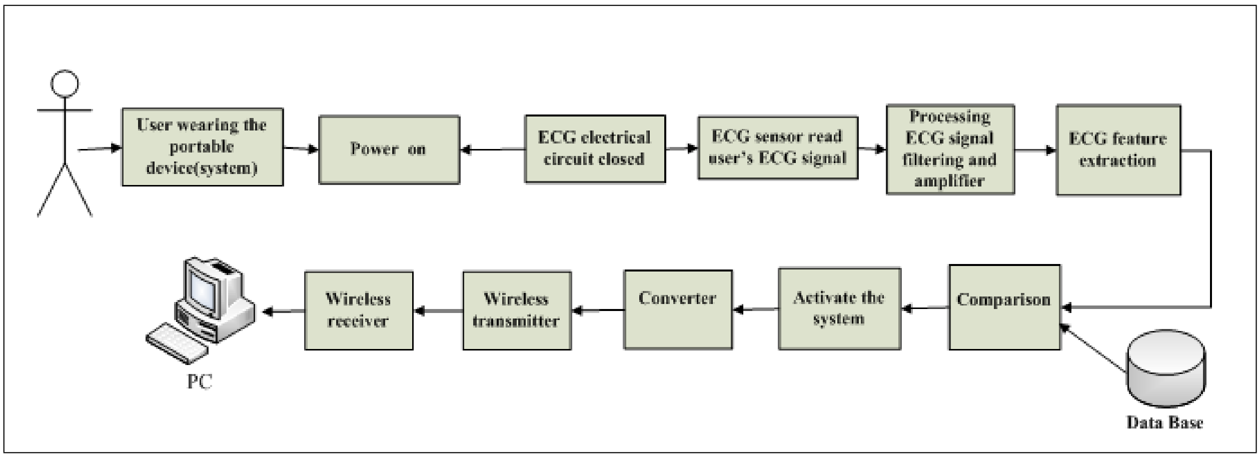

Figure 5.1: System block diagram.

5.2 Objects relational model (software components)

Objects relational model diagram is shown in figure(5.2).

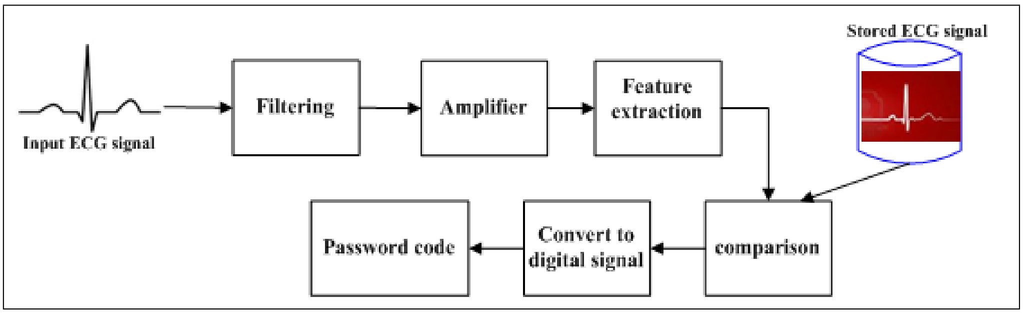

Figure 5.2: Objects relational model diagram.

5.3 State behavioral modeling

5.3.1 Control flow

Control flow is shown in figure(5.3).

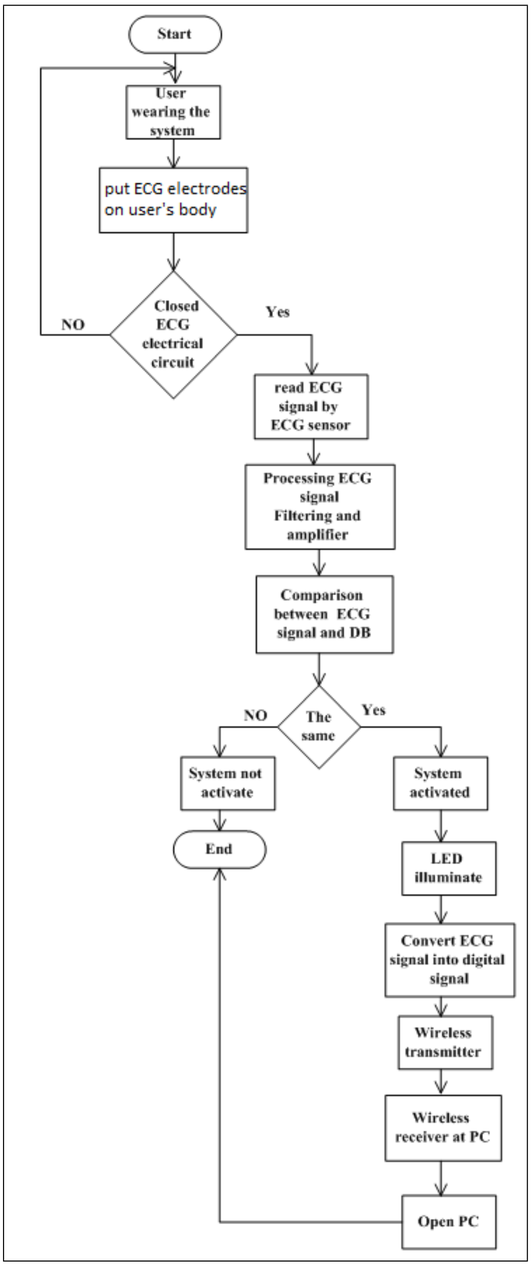

Figure 5.3: Control flow diagram.

5.3.2 Data flow

Data flow is shown in figure(5.4).

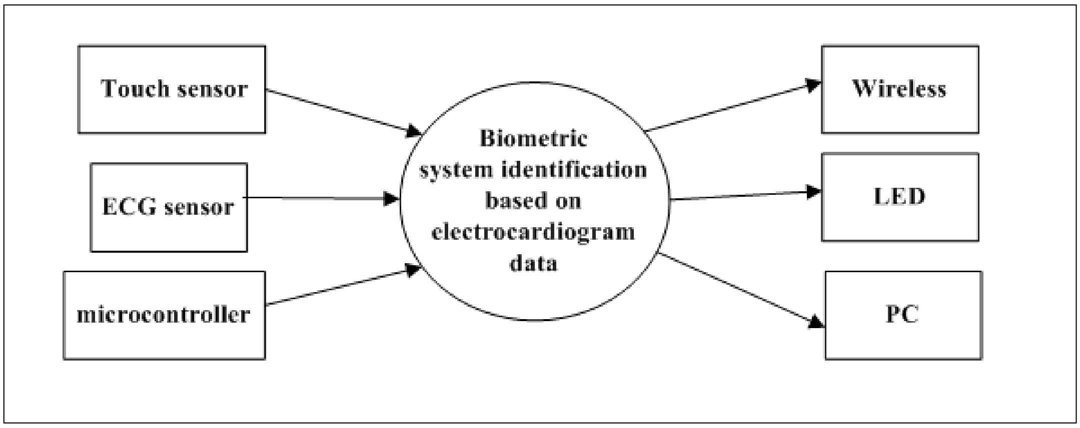

Figure 5.4: DFD diagram.

5.3.3 State flow

State flow is shown in figure(5.5).

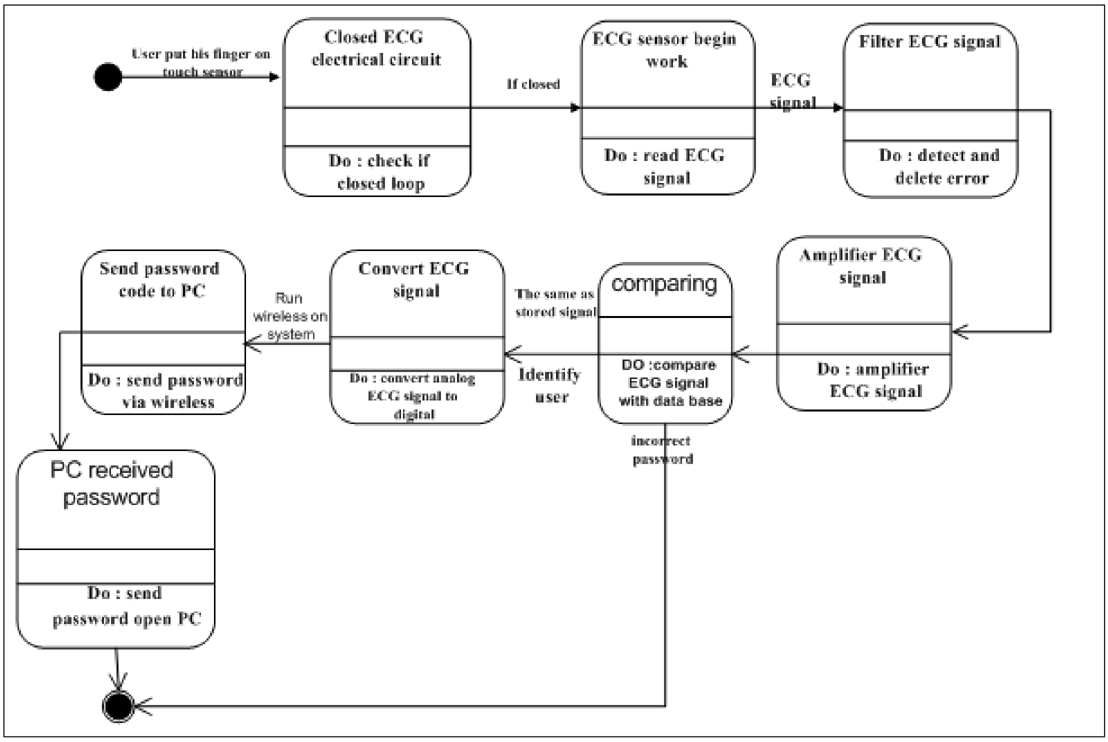

Figure 5.5: State flow diagram.

5.4 Subsystem design

This section shows the diagram of subsystem design.figure(5.6). Our system consists of two subsystem :

1. User interaction : The user deal with the system using two subsystems:
   - Wearing portable device around his wirstband.
   - Power on to generate power on portable device , so device start its work .
   - Deactivate the system , this user can do it by put the system far away from his waistband , so no sensing , no power in system , and the system become turn off .
2. Control unit :The system consist of subsystem that deals with hardware component, to reach the aim of the system, this will be by the following subsystem :

- Processing : The raw signal must be process to get the desired signal without noise using filtering, and amplified it, to make signal more powerful , using amplifier.
- Sensing : the system read ECG signal from user wristband, this require touching sensor to closing ECG electrical circuit , and ECG sensor to sensing and read ECG signal from user waistband .
- Converting :The system must transfer password code, to interact with PC as password, the converter convert analog ECG signal to binary code, so PC can deal with it.
- Illumination : This subsystem used to show that the system is active or not, by give us an light as alert of working system.

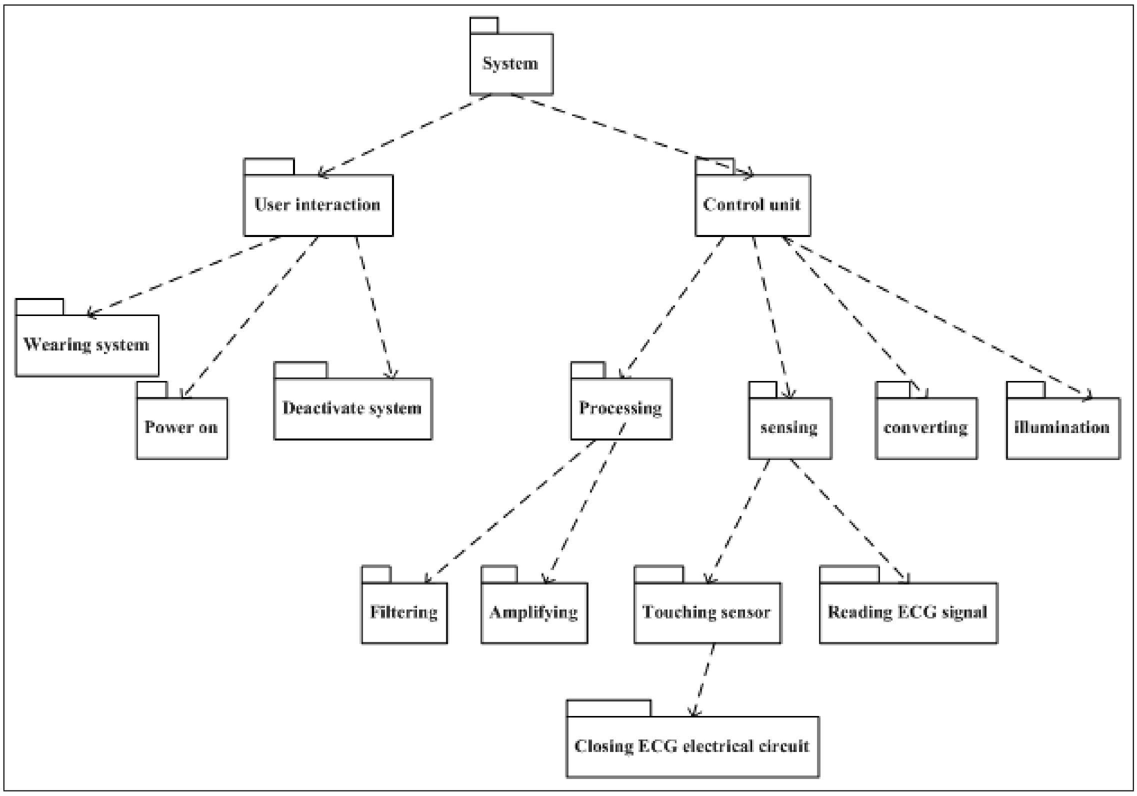

Figure 5.6: Subsystem diagram.

5.5 Class and object design

User
- ID : int + Name : string + paswword code : string + mobile number : int + location : string
Activate system () : void Deactivate system () : void

Table 5.1: User class.

Touch sensor
- ID : int + Name : string + Type: string
+Sensing user's wirstband () : void

Table 5.2: Touch sensor class.

ECG sensor
- ID : int + Name : string + Type: string
+Read user's ECG () :void

Table 5.3: ECG sensor class.

Converter
- ID : int + Name : string + Type: string
Convert ECG signal into digital signal(password code) () :void

Table 5.4: Converter class.

Wireless
- ID : int + Name : string + Type: string
+Transfer password code through it to PC () :void

Table 5.5: Wireless class.

- **Activate system**: closed the ECG electrical circuit to reading ECG signal.
- **Deactivate system**: turn system off.
- **Sensing skin (wristband) of user**: the user put his finger on touch sensor to closed the ECG electrical circuit.
- **Read ECG sensor:** read the ECG signal from user hand.
- **Convert ECG signal into digital signal** : convert analog ECG signal to digital signal , as machine language.
- **Transfer password code through it** :transfer the password code to computer to compare it with the original code .

Personal computer
- ID : int + Name : string + Type: string + Memory speed : int +Serial number : int
+Receives password code() :void +Run () :void + Start operation on it() : void

Table 5.6: Personal computer class.

- **Personal computer class** : received password code and open.

5.6 software interface design

This section shows the object interfacing and user interface design if exist in the system.

5.6.1 Object interfacing

In our project there is no software interface.

5.6.2 User interface design

In our project user not have any privileges in software, he doesn't made any interface , but may be in future we will add an software program , so user can deal with system through it as interface.

5.7 Hardware interface design

This section shows the component interfacing and user interface design if exist in the system.

5.7.1 Component interfacing

This section shows component hardware interface. In our system there is two hardware interface , wireless and touch sensor. Wireless is connection between system and PC, it transfer password code from system to PC. Touch sensor is sensing user's finger, and use it to close ECG electrical circuit of the system, so system begin work.See figure(5.7).

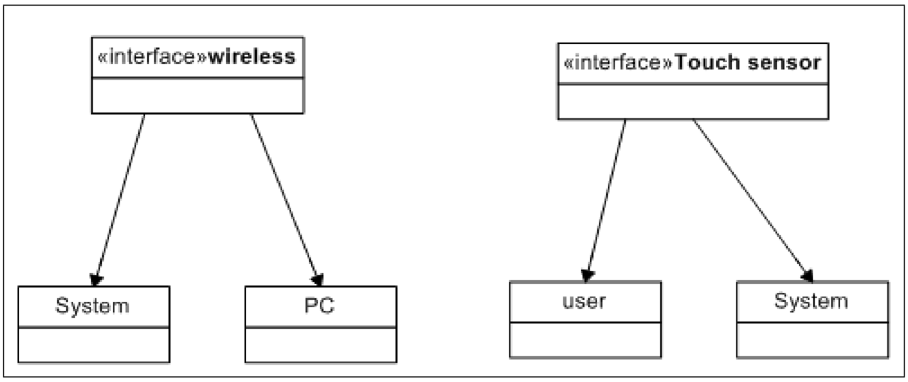

Figure 5.7: Component interface design.

5.7.2 User interface design

This section shows user interface design in hardware component. In our system there is to interface between user and hardware, finger and wristband of user. User wearing system on his wristband , user's wristband attach ECG sensor , so sensor can read ECG from it , user put his finger above touch sensor, to close ECG electrical circuit, so system work correctly.(5.8).

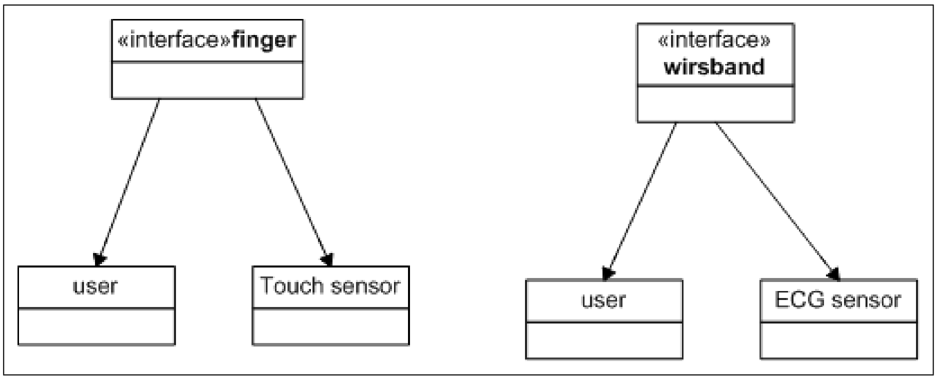

Figure 5.8: User interface design.

5.8 Summary

In this chapter we talked about objects-relational model for the software components, state behavioral modeling that include control flow , data flow and state flow, chapter show subsystem design so that it have a description of each subsystem's tasks and components, software and hardware, also chapter talked about class and object design, interface design for both software and hardware components.

Chapter 6

Hardware and software implementation

6.1 Introduction

This chapter describes the hardware and software implementation of the system .The system can be divided into four main parts : reading ECG signal , Bluetooth communication with PC , (C) charp software program as application of the system , and software that contation processing of the system.Each one of these parts will be described in details in this chapter .

6.2 Hardware Implementation

6.2.1 Aurdino Implementation

1. **Get an Arduino board and USB cable.**
   We use in our project Arduino Uno, Arduino Duemilanove, and Arduino Mega 2560 in the test trying to choose the best one to use in our project .All of this have the same implementation .

2. **Download the Arduino environment.**
   This sotware used to write the code in side it and then download code to Aurdino .

3. **Connect the board The Arduino Uno, Mega, and Duemilanove.**
   Automatically draw power from either the USB connection to the computer or an external power supply. When we connect the Arduino board to computer using the USB cable. The green power LED go on.

4. **Install the drivers.**

   - Plug in the board and wait for Windows to begin it's driver installation process.
   - **Click on the Start Menu, and open up the Control Panel.**
   - open the Device Manager.
   - under Ports (COM) the name of Aurdino typee will appear "Arduino UNO, Mega, and Duemilanove (COMxx)"
   - Right click on one of the "Arduino type that will we use (COmxx)" and we choose the "Update Driver Software" option.
   - choose the "Browse my computer for Driver software" option.
   - Windows will finish up the driver installation from there.

5. Launch the Arduino application
   Double-click the Arduino application and open it .

6. **Open the blink example**
   Open the LED blink example sketch: 1.File 2.Examples 3.Basics 4.Blink. see figure(6.1).

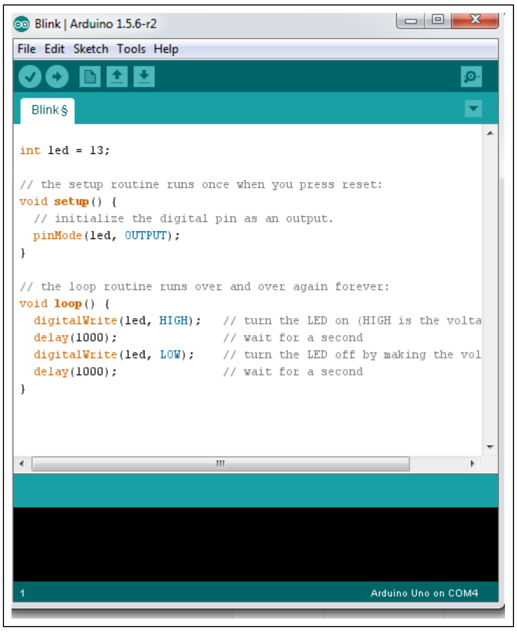

Figure 6.1: Blink example

7. **Select the board that we will use and select our serial port.** we'll need to select the entry in the Tools ¿ Board menu that corresponds to our Arduino.Select the serial device of the Arduino board from the Tools — Serial Port menu. This is likely to be COM3 or higher (COM1 and COM2 are usually reserved for hardware serial ports).

8. **Upload the program.** click the "Upload" button in the environmen . If the upload is successful, the message "Done uploading." will appear in the status bar. A few seconds after the upload finishes, the pin 13 (L) LED on the board start to blink. see figure(6.2).

Figure 6.2: Blink of LED.

6.2.2 E-health Sensor Implementation.

6.2.2.1 ECG sensor features

The electrocardiogram (ECG) is a diagnostic tool that is routinely used to assess the electrical and muscular functions of the hear. The Electrocardiogram Sensor (ECG) has grown to be one of the most commonly used medical tests in modern medicine. Its utility in the diagnosis of a myriad of cardiac pathologies ranging from myocardial ischemia and infarction to syncope and palpitations has been invaluable to clinicians for decades. The accuracy of the ECG depends on the condition being tested. A heart problem may not always show up on the ECG. Some heart conditions never produce any specific ECG changes. ECG leads are attached to the body while the person lies flat on a bed or table.

Steps to use the e-health sensor to measure ECG signal:

1. Connect the three leads (positive, negative and neutral) in the e-Health board as figure(6.3).

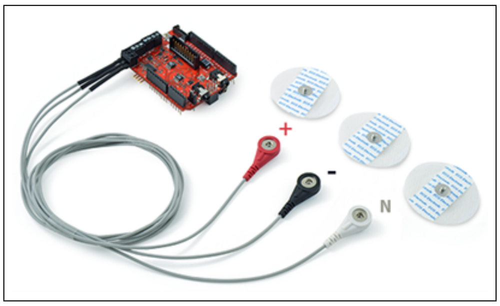

Figure 6.3: Connect the Leads in e-health.

2. Place the electrodes as shown in figure (6.4).

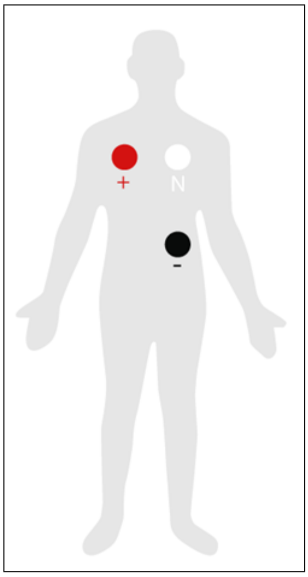

Figure 6.4: Connect the electrodes in the body.

3. Download library functions into aurduino environment ,so we can use function to return value of ECG , This ECG returns an analogic value in volts (0 – 5) to represent the ECG waveform.

6.2.3 Build ECG Circuit

This circuit consist of resistors , capacitors , filter and amplifier , ECG signal is in mv and may it contain noise, so after it go through this circuit it will be in volt and without noise.

1. Draw the circuit on protues program as in figure(6.5).

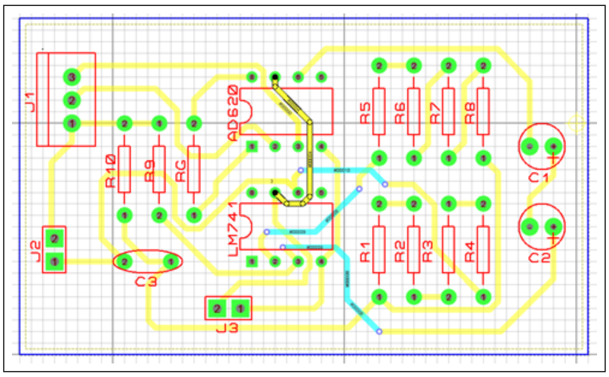

Figure 6.5: ECG circuit on Protues program.

2. Build the circuit in bread board.
   Build it in bread board and connect it to ECG simulation or to ECG electrodes, so we can input ECG signal to the circuit and draw it to oscillator device.See figure(6.6)

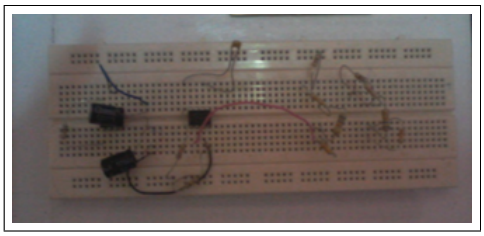

Figure 6.6: ECG circuit on breadboard.

3. Print circuit on PCB as in figure (6.7).

4. Collect and put all component on the cuircuit as in figure (6.8).

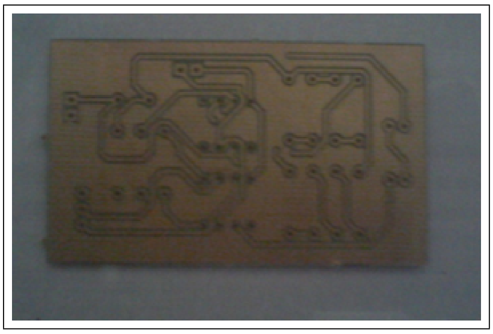

Figure 6.7: ECG circuit on PCB.

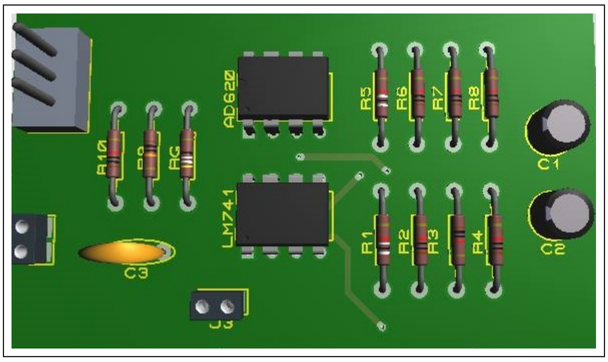

Figure 6.8: Complete ECG circuit.

6.2.4 Bluetooth module Implementation.

The bluetooth module we will use is HC-05 which is so familiar and cheap, arduino support Software Serial, which allow us to change any arduino board pin to serial pin ,we implement blootouth in Arduino Uno, Arduino Duemilanove, and Arduino Mega 2560 and all the type the same steps .

1. Connect blootouth module with aurdino as figure(6.9).
2. Connect aurdino with the PC via USB cable .
3. Set up PC for serial Bluetooth communication.
   (1) Click control panel - Add device .
   (2) blootouth on PC start searching for bluetooth device , when it find our blootouth module , we should click on bluetooth module.
   (3) PC will ask to enter blootouth device pairing code , it is 1234 .
   (4) Succesfully conection between PC and bluetooth module.

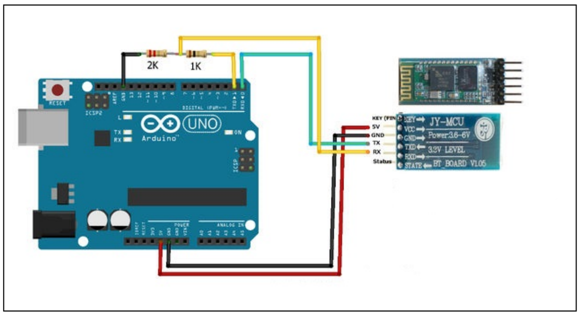

Figure 6.9: Connect Blootouth to Aurdino.

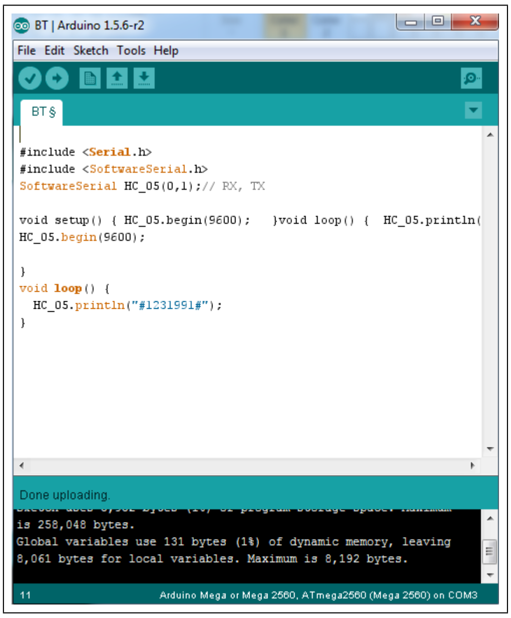

Figure 6.10: Arduino test sketches of bluetooth.

4. Load the Arduino test sketches of bluetooth as figure(6.10).

5. Bluetooth module will transmite 1231991 to PC .

6.3 Software Implementation

6.3.1 Matlab code

The ECG based biometric verification is a procedural of verifying the identity of user. It demonstrates by comparison one to one feature stored in database for real person signal and feature currently reading using ECG sensor. Software part use two languages use matlab for test, and c language for identification. The software part was implemented by more than step: the first step record ECG signal from user by ECG hardware recorder, and remove noise from signal, then extraction of features to recording verification.

1. **First step: read ECG signal and remove noise as figure(6.22).**

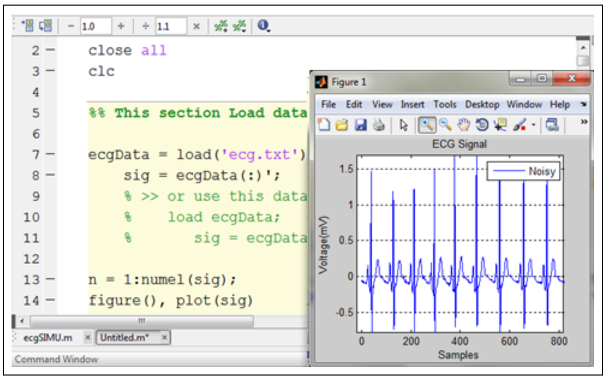

Figure 6.11: Read ECG signal.

2. **Second step: if the signal not centered on x-axies, we need to trend as figure(6.12).**

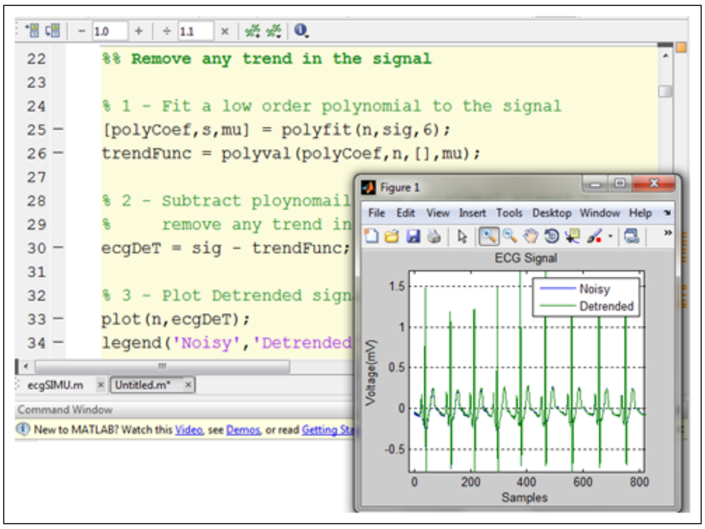

Figure 6.12: Trend ECG signal.

3. **Third step: we attempt to reduce the noise by a process called smoothing as figure(6.13).**

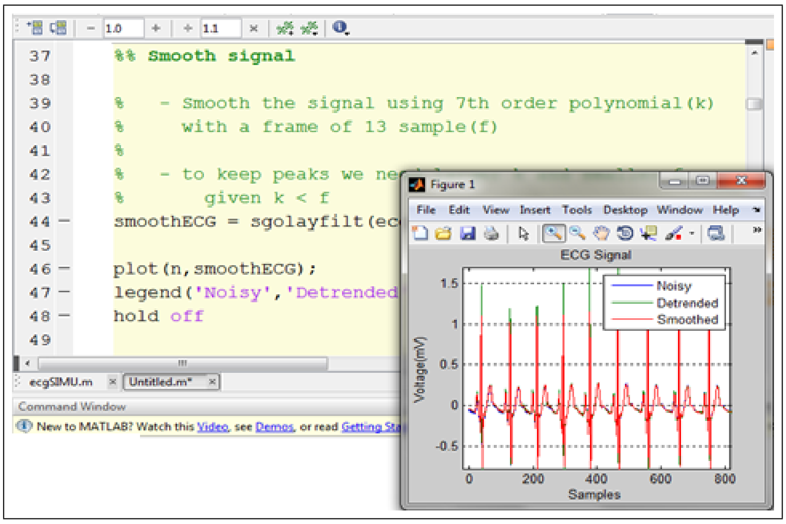

Figure 6.13: Smoothing ECG signal.

In our project, the seven amplitude ECG features, PR amplitude, QR amplitude, RS amplitude, RT amplitude, PS amplitude and TS amplitude as figure(6.14).

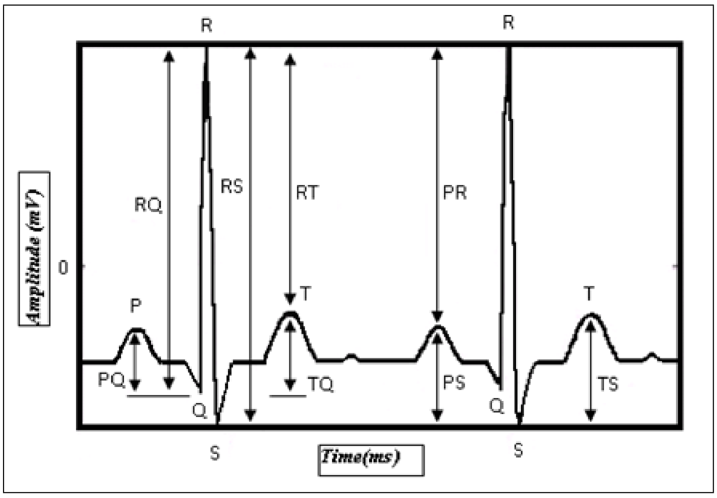

Figure 6.14: All amplitude features extraction.

The above features were selected because it has been observed that heartbeat of a person changes from infant to adult person, so the time duration between various peaks and valleys changes. Also amplitude features have minimum changes with age so mostly amplitude features were selected. For feature extraction, the R peak in the waveform was detected using a find peak code. Their peak before it is a P peak ,less than amplitude ,and peak after the R peak is the T peak, it more than P peak amplitude. The distance of two R peaks was measured by using index of array. The valley between the P and R peaks is Q and valley between the R and T peaks is S. To feature extraction, in the first we need to find all peaks in ECG signal as follow:

1. Find R peak by findpeaks code as figure(6.15).

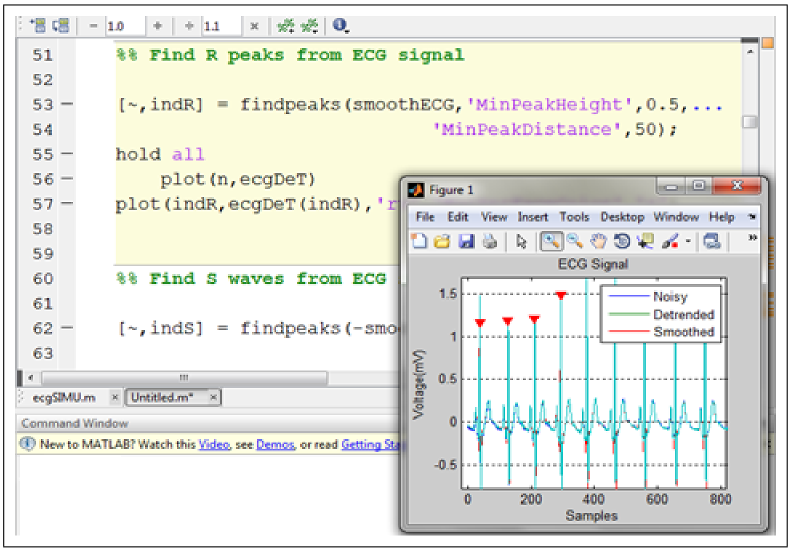

Figure 6.15: Find R peak.

2. Find S peak as figure(6.16).

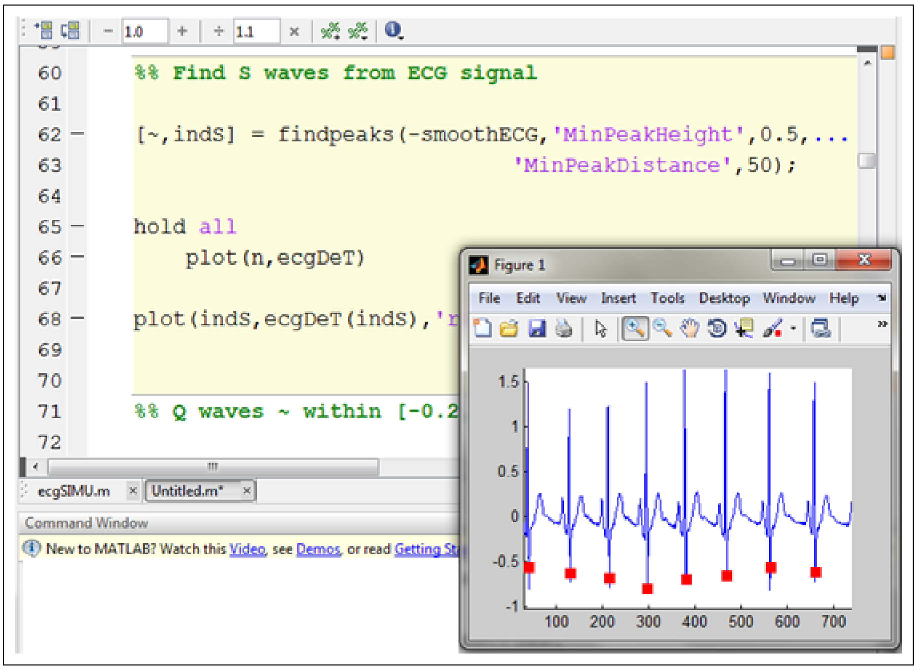

Figure 6.16: Find S peak.

3. Find Q peak as figure(6.17).

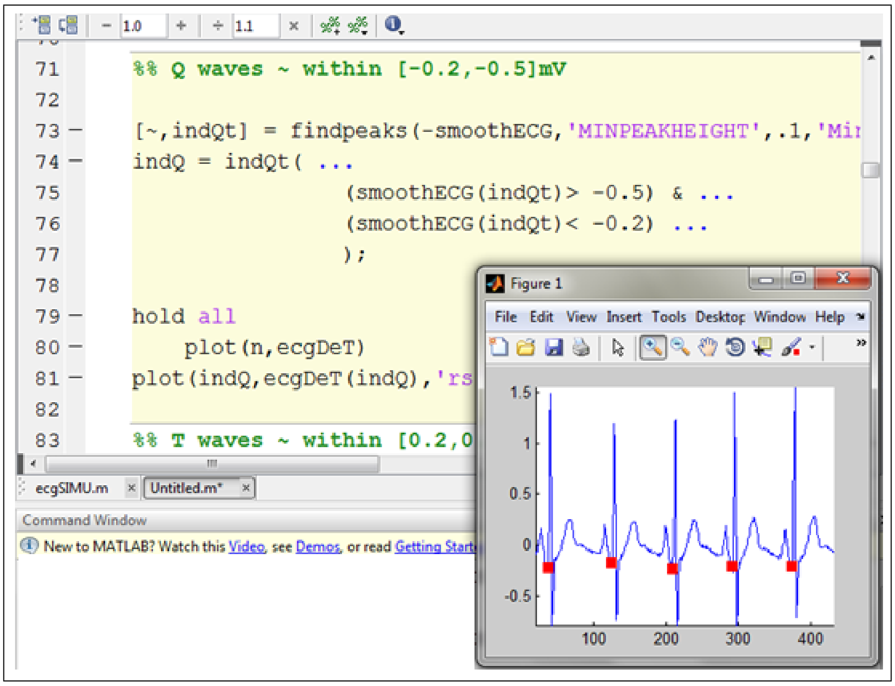

Figure 6.17: Find Q peak.

4. Find T peak as figure(6.18).

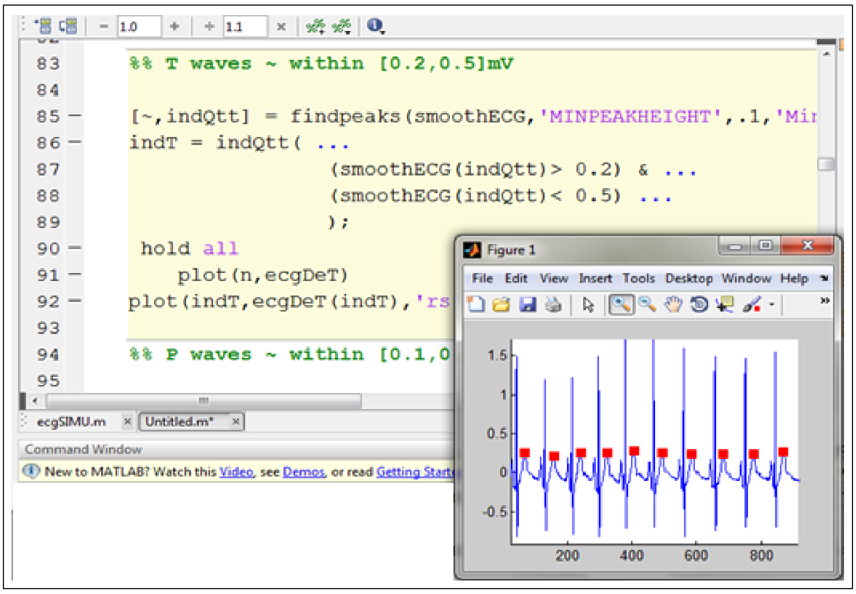

Figure 6.18: Find T peak.

5. Find P peak as figure(6.19).

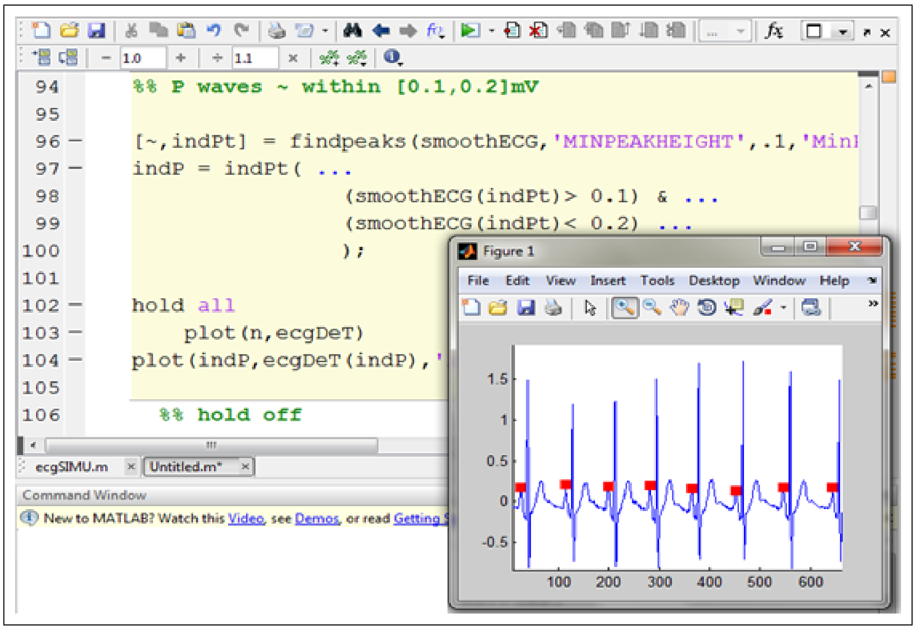

Figure 6.19: Find P peak.

6. Find all peaks in the signal as figure(6.20).

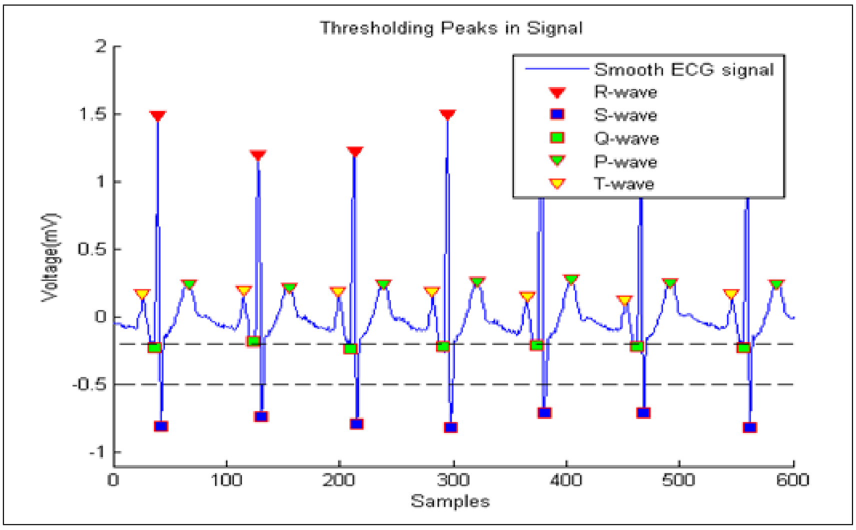

Figure 6.20: Find all peaks in the signal.

6.3.2 Arduino code

We convert all matlab code to arduino so we can download it to arduino due in steps that mention earlier , see figure(6.21).

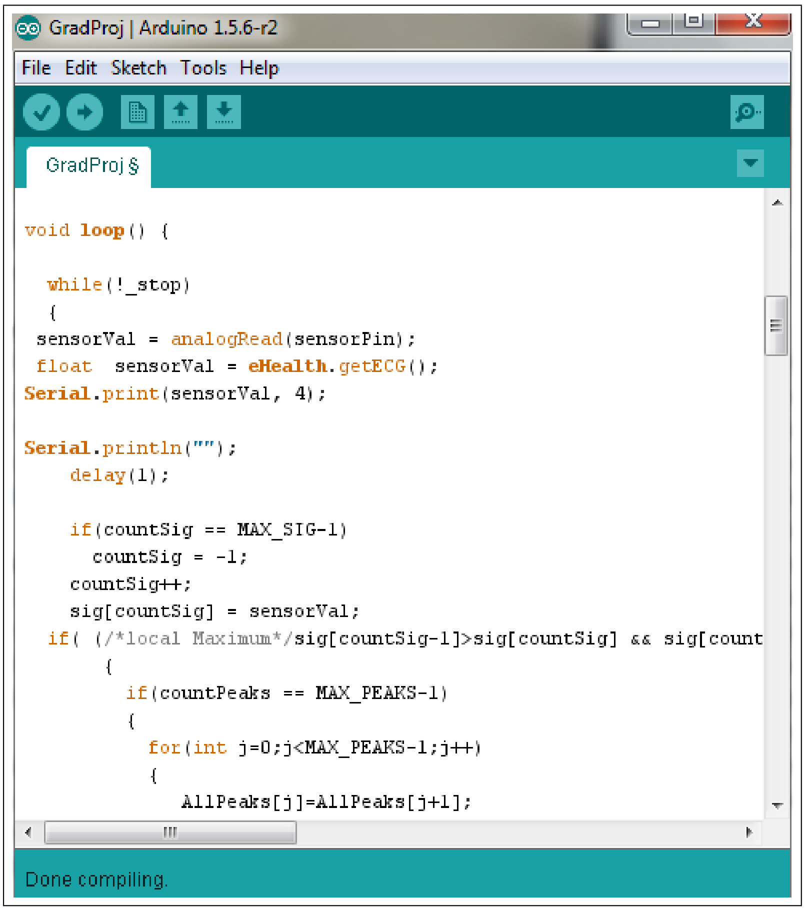

Figure 6.21: Arduino code.

6.3.3 C charp application

C charp application will receive password that send from bluetooth and will open facebook account . The appllication interface is in figure.(6.22).

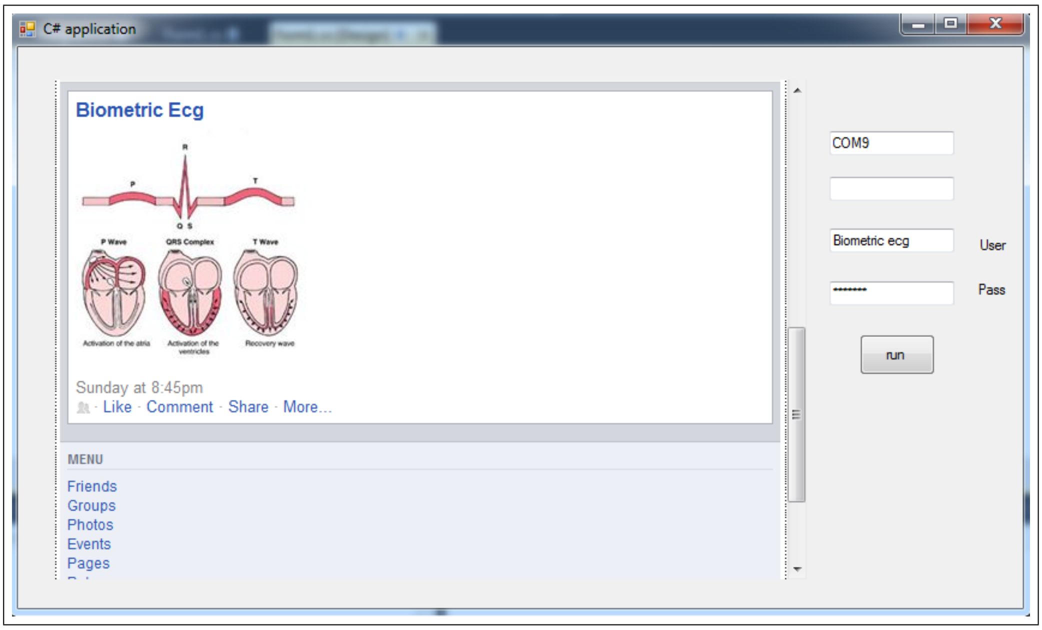

Figure 6.22: C charp application.

6.4 Summary

This chapter describes the hardware and software implementation of the system .

Chapter 7

Test project

7.1 Hardware Test

7.1.1 Bluetooth test

Connect bluetooth to PC and blink led if it transmite the data . first connect bluetooth to arduino and downloade code for transmite the password ,and after connect hardware downloade the software to arduino , then bluetooth will send 1231991 and this code is the password of facebook acoount , all these steps is shown in c charp application test.

7.1.2 Arduino test

Test Arduino Mega and Arduino due to see that it is work correctly , the test is the same for the both arduino type. This example shows the simplest thing you can do with an Arduino to see physical output , it blinks an LED.

Circuit To build the circuit, we attach a 220-ohm resistor to pin 13. Then we attach the long leg of an LED to the resistor.The short leg Attachedto ground (the negative leg, called the cathode). Then we plug Arduino board into computer, start the Arduino program, and write the code as figure(7.1). Most Arduino boards already have an LED attached to pin 13 on the board itself see figure(7.2).

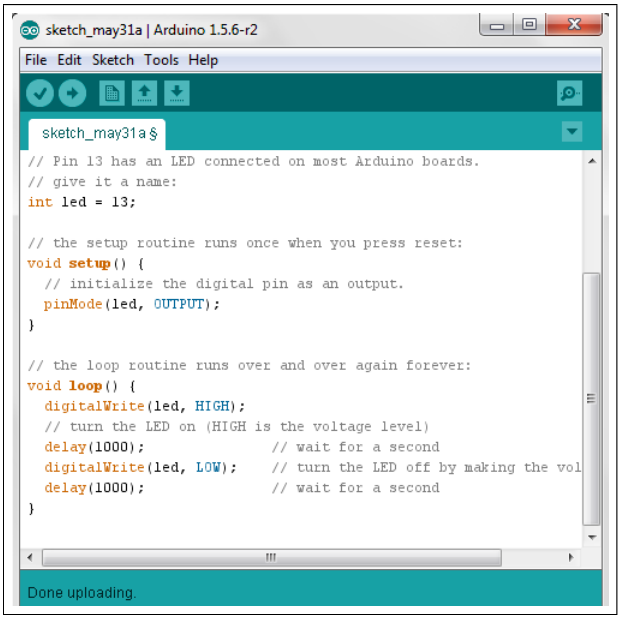

Figure 7.1: Arduino test code.

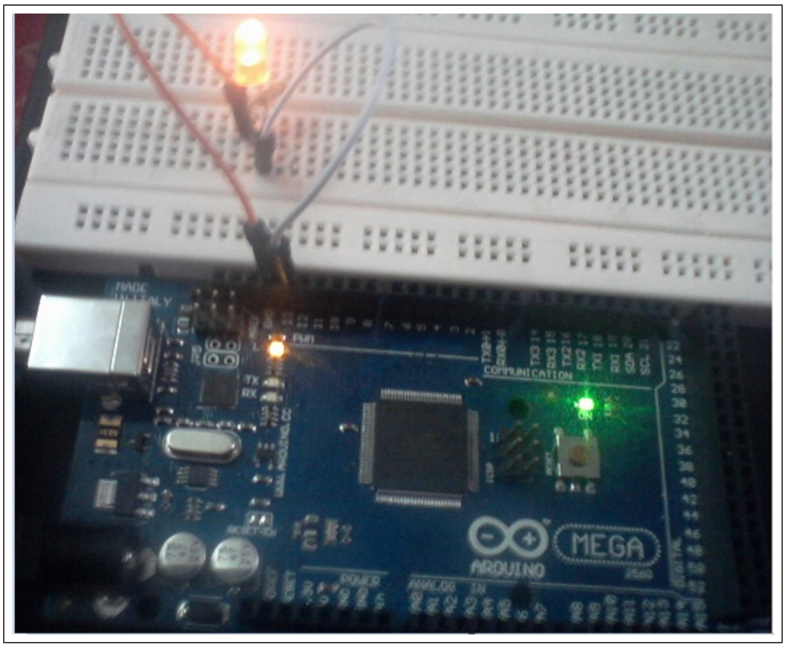

Figure 7.2: Arduino test hardware.

7.1.3 E-health Sensor test.

First we connect electrode to e-health sensor sheild and put it on the user's body, then we write an software code on arduino code and download it to arduino mega ,code in figure (7.3), it output an digital value of ECG signal as figure(7.4) , we test to take the signal from 2 different place .

First : take signal from the user's hand

To try to find if it is possible to measure ECG from two lead , but the result was not as we want , signal is contain alot of noise , we can draw output digital signal, see figure(7.5).

Second : take signal from the user's body

In this way , the signal more clear than the first one , this way as same as measure from lead 2 , output will more clear than the first one as figure(7.6)

Figure 7.3: Arduino test code for e-health.

7.1.4 ECG Circuit.

ECG circuit consist of many hardware component , we input th ECG signal to this circuit trying to output an correct ECG signal. but the output signal is appear wrong , the connection and the output is shown in figures (7.7),(7.8) , circuit of ECG doesnt work correctly and its fault so we cant use it in our project .

```
ECG value :  1.69 V
ECG value :  1.69 V
ECG value :  1.70 V
ECG value :  1.70 V
ECG value :  1.69 V
ECG value :  1.68 V
ECG value :  1.67 V
ECG value :  1.67 V
ECG value :  1.67 V
ECG value :  1.67 V
ECG value :  1.68 V
ECG value :  1.69 V
ECG value :  1.69 V
ECG value :  1.70 V
ECG value :  1.70 V
ECG value :  1.69 V
ECG value :  1.68 V
ECG value :  1.67 V
ECG value :  1.67 V
ECG value :  1.67 V
ECG value :  1.67 V
ECG value :  1.68 V
ECG value :  1.69 V
ECG value :  1.70 V
ECG value :  1.70 V
ECG value :  1.70 V
ECG value :  1.69 V
ECG value :  1.69 V
ECG value :  1.67 V
ECG value :  1.67 V
ECG value :  1.67 V
ECG value :  1.67 V
ECG value :  1.68 V
ECG value :  1.69 V
ECG value :  1.70 V
```

Figure 7.4: Output digital ECG signal from e-health.

7.2 Software test

7.2.1 Matlab test

Test were performed on the database for 10 individuals having 10 samples each and the results a false rejection rate of 0.05 and false acceptance rate 0.06. We try verifying use ECG waveform as a biometric. After take ECG signal from hardware and remove noise by hardware and software filter, then we extract a set of temporal and amplitude features from ECG eafeform. The extracted features from the ECG signal were compared one by one with the features of the real person already stored in database. If any specific feature and its corresponding feature stored in the database lies within autocorrelation function, then it was assumed that the two features matched with each other. We tested all seven features for matching. The decision was taken for user, and we considers real one if a minimum 5 out of 7 features of the subject were matched, access was then provided to the application, otherwise access was denied.

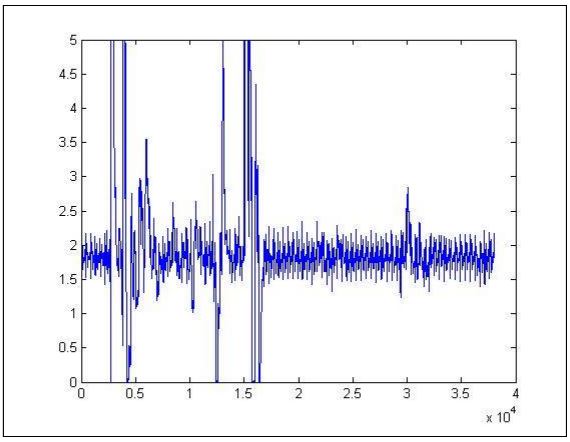

Figure 7.5: Output ECG signal from 2 lead.

Values of extracted features of all 10 subjects areshown in figure (7.9).and the results of the verification systemare shown in figure (7.10).

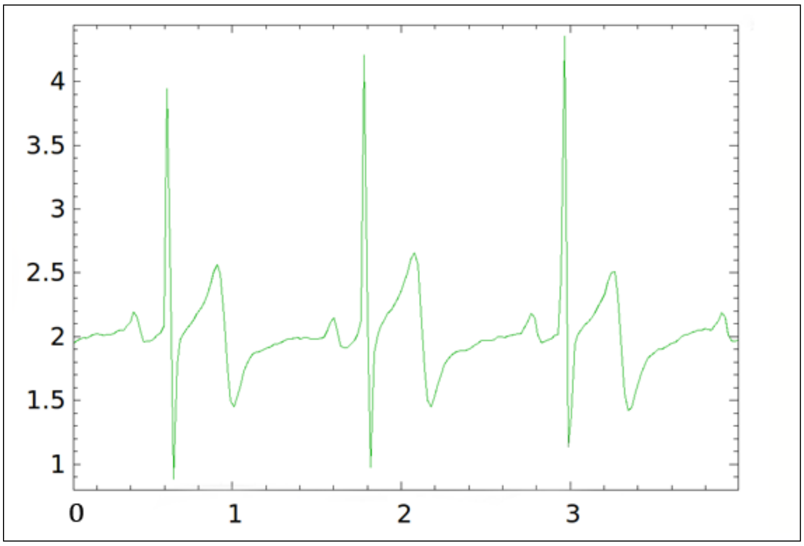

Figure 7.6: E-health output signal.

Figure 7.7: ECG circuit test.

In figure(7.10)the diagonal reading in boldpresents the number of matched samples of a subject with itself which shows the true accept cases i.e. the accuracy ofthe system, the off diagonal readings show the number ofmatched samples with other subjects i.e. false accepts of thesystem.As shown in figure(7.11) the experiments were performedon the collected database 10 persons ofdifferent ages having 10 samples from each person.

Figure 7.8: ECG circuit test.

Sample	features							
	PR	RQ	PQ	RS	TS	RT	TQ	PS
Sample1	1.3150	1.7100	0.3950	2.2950	1.0600	1.2350	0.4750	0.9800
Sample2	2.2450	3.0400	0.7950	10.7200	8.6400	2.0800	0.9600	8.4750
Sample3	0.3200	0.8000	0.4800	1.9200	1.7600	0.1600	0.6400	1.6000
Sample4	5.9200	10.4000	4.4800	10.4000	4.6400	5.7600	4.6400	4.4800
Sample5	1.0768	5.8456	4.7687	3.3792	1.0939	2.2854	3.5602	2.3024
Sample6	1.1657	4.4245	3.2588	4.4245	2.5266	1.8979	2.5266	3.2588
Sample7	1.1960	3.3959	2.1999	2.4313	0.0000	0.0000	0.0000	1.2353
Sample8	11.8000	14.8800	3.0800	12.1600	1.1200	11.0400	3.8400	0.3600
Sample9	1.0768	5.8456	4.7687	3.3792	1.0939	2.2854	3.5602	2.3024

Figure 7.9: Value of feature extraction.

	Sample1	Sample2	Sample3	Sample4	Sample5	Sample6	Sample7	Sample8	Sample9
Sample1	9	0	0	0	1	2	0	0	0
Sample2	2	9	0	0	0	0	0	0	2
Sample3	0	0	9	0	1	0	0	2	0
Sample4	0	1	0	9	2	0	0	0	0
Sample5	0	0	0	0	9	0	0	0	0
Sample6	0	0	0	0	1	9	0	0	0
Sample7	0	0	0	2	0	0	9	0	0
Sample8	0	2	0	0	0	1	0	9	0
Sample9	0	0	0	0	0	2	1	0	9

Figure 7.10: The Result Of Verification.

7.2.2 Application test

We try more than language to make a connection between bluetooth and the PC , transmite the code to PC ,the application on PC will receive code

Total number of person	True test per person	Total true test	Total false reject	%false reject
9	9	81	6	3

Figure 7.11: The Total Result Of Verification.

from bluetooth module ,if is the same password it will open facebook acount , website as users want . first connect bluetooth to arduino as (7.12) then downloade code for transmite the password as figure (7.13).

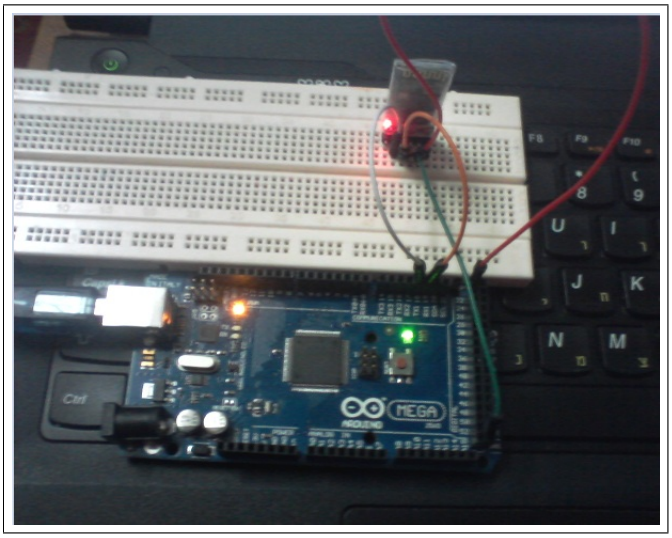

Figure 7.12: Bluetooth hardware test.

, and after connect hardware downloade the software to arduino, then bluetooth will send 1231991 and this code is the password of facebook acoount .After these steps bluetooth will connect to PC as the following steps :

1. Add bluetooth device as figure (7.14).
2. Select pairing options as figure (7.15).
3. Enter pairing options as figure (7.16).
4. Device succesfully added to PC as figure (7.17).

after these steps check at which port the bluetooth connect to PC as figure (7.18).
We will use this port in c charp connection as figure (7.19).
User put the name of acount and password after received succesfully , acount will open as figure (7.20).

Figure 7.13: Bluetooth code test.

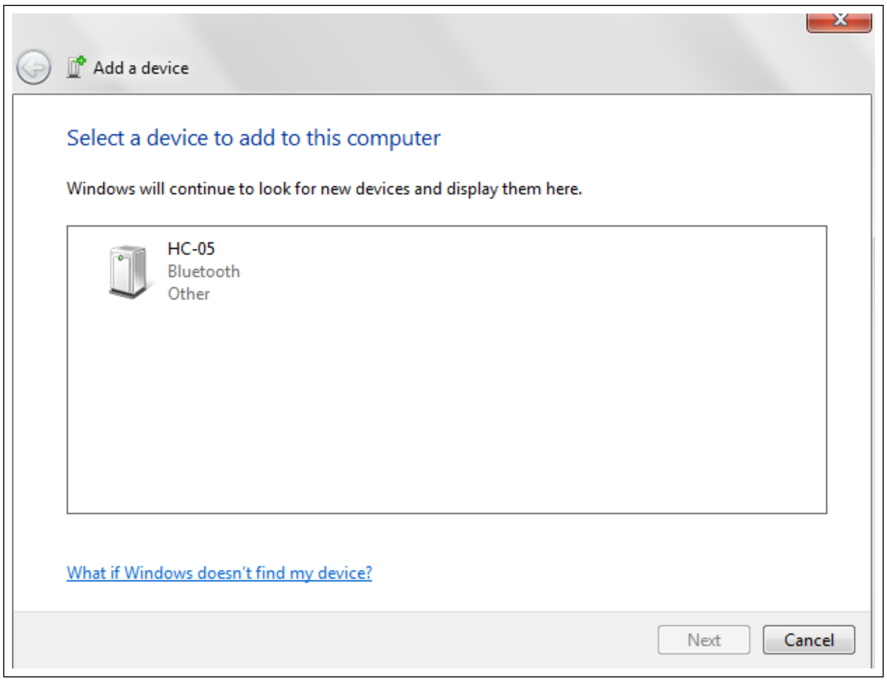

Figure 7.14: Add bluetooth device.

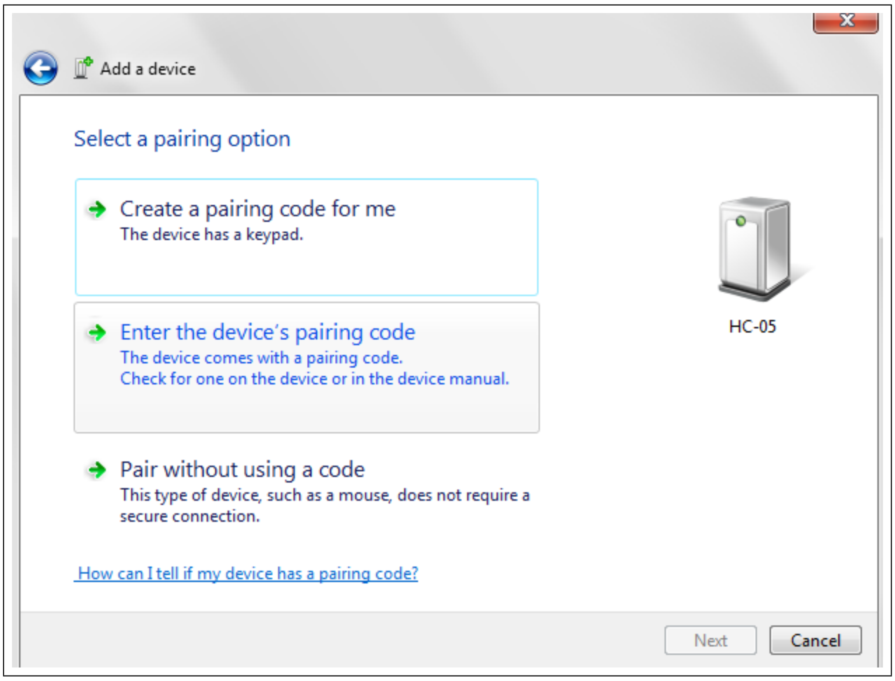

Figure 7.15: Select pairing options.

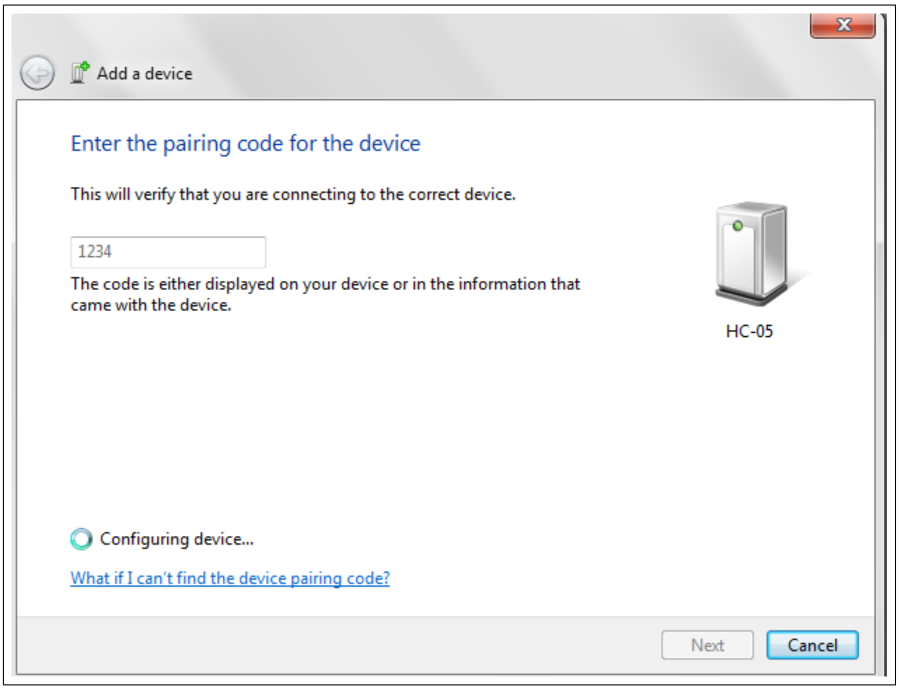

Figure 7.16: Enter pairing options.

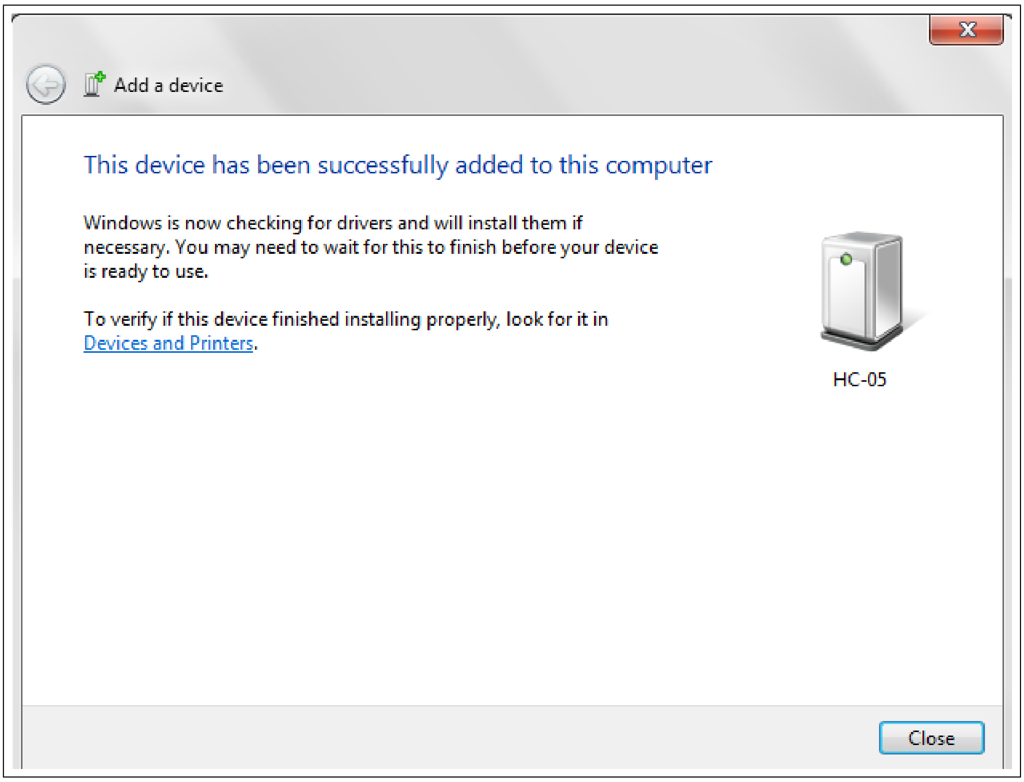

Figure 7.17: Device succesfully added to PC.

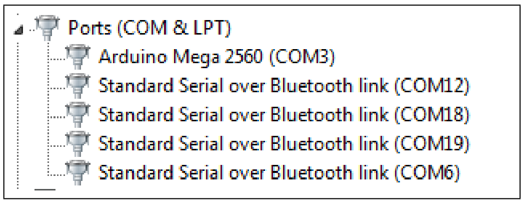

Figure 7.18: Standard serial over bluetooth link.

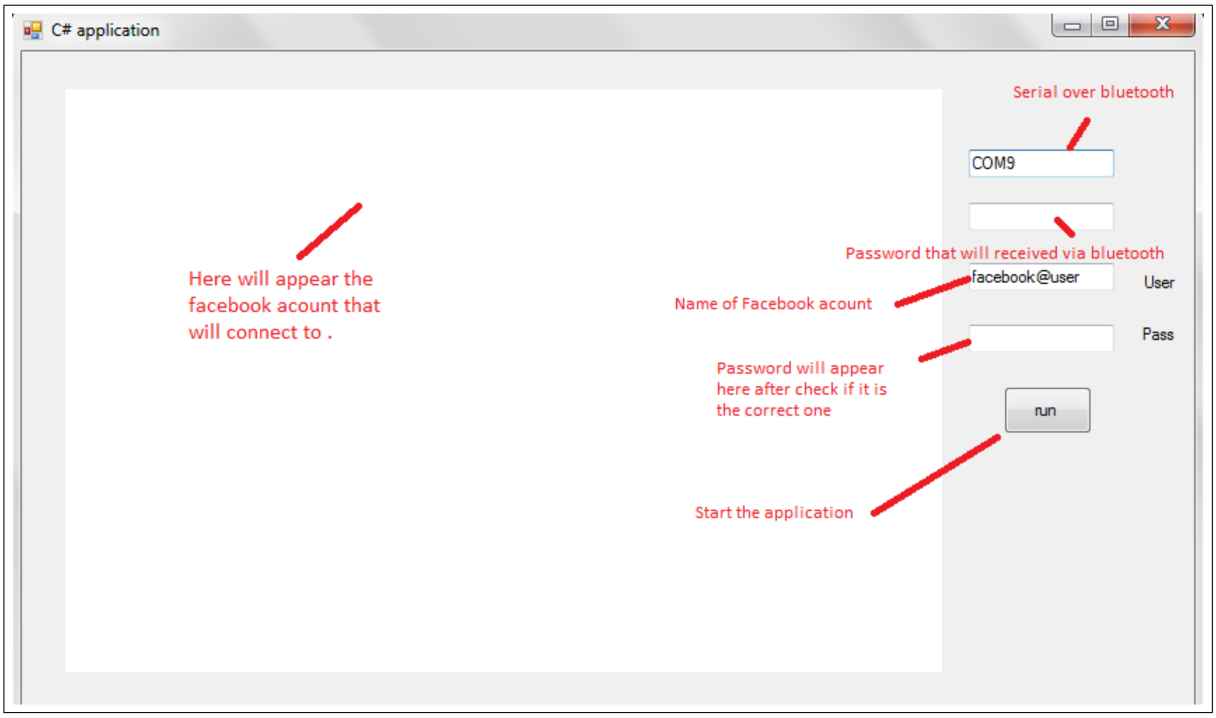

Figure 7.19: C charp application.

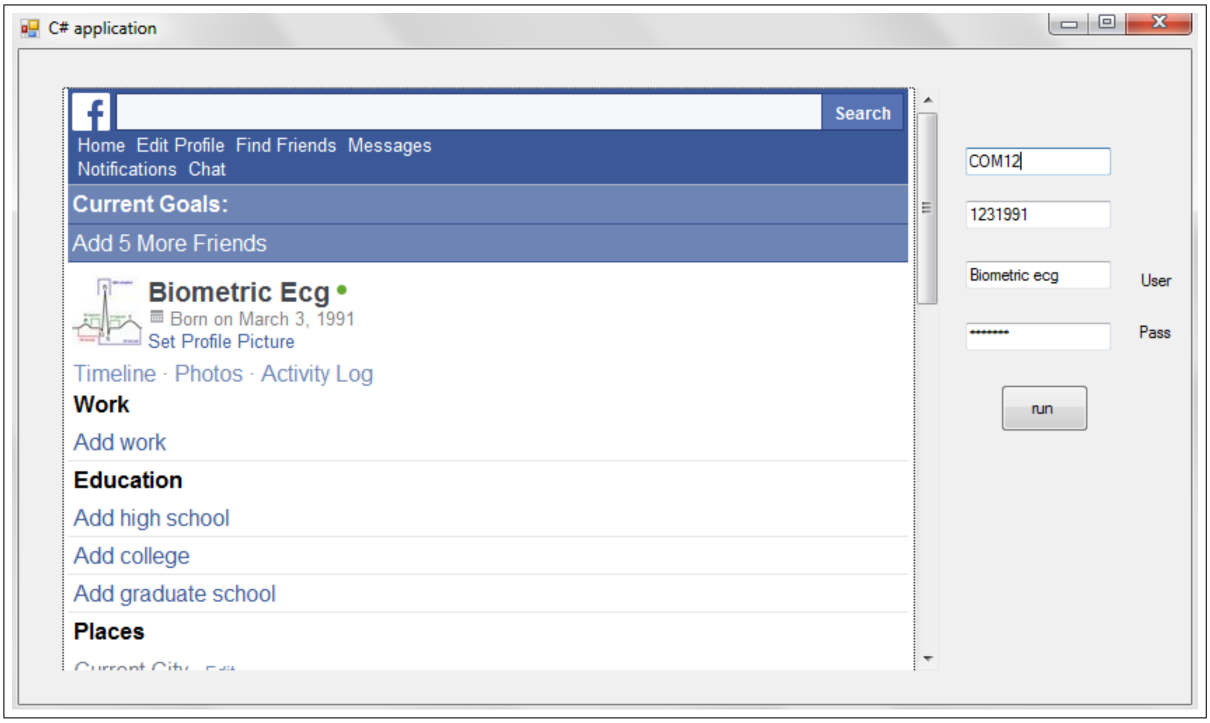

Figure 7.20: Open facebook acount.

Chapter 8

Conclusion and Recommendations

8.1 Overview

This chapter describes the real learning outcomes have been acquired during the work on the project , and recommendations and suggestions for future work and development .

8.2 Problems

ManyProblems, challenges , and issues have been raised during the work on the project . many experiments , suggestions , ideas and researches have been carried out to deal with the different situations. Some of these problems are :

1. The availability of the quantity and the quality of some of the project's equipment .
2. Slow response in the system and because of treatment process.
3. Big time spent in the programming process and learn the appropriate programming language .
4. Size of the project may be large relative to the size of the portable device.

8.3 Acquired Learning Outcomes

After accomplishing the project tasks may talents and abilities have been achieved as :

1. We have learn aurdino programming language that is used to program the microcontroller.
2. We have learnt c sharp programming language.
3. We have developed our abilities in troubleshooting and problem solving.

8.4 Conclusion

We achieved a good result in identify one person from another at matlab code , Software can measure all amplitude feature that is unique to each person .

8.5 Future Work

1. Work to increase the responsiveness and speed as much as possible , as well as increase the coverage.
2. Work on development of the software interface so that it becomes the most beautiful.
3. Work to reduce the size as much as possible as well as increase functions of the portable device .
4. Linking this project with many device to control them like mobile .

8.6 Recommendations

At the end, some ideas can be given to develop the system or extend it duties and functions, and some recommendations can be given to avoid the problems that may happen in the future as :

1. If the project has a hardware part, try to get all the components of the project at the preparation stage not to postpone it to last moment.
2. To be a group of students to serve parts of the project , each one according to his specialty.
3. Distribute a group of students to serve parts of the project ,

8.7 Summary

This chapter describes the real learning outcomes have been acquired during the work on the project , and recommendations and suggestions for future work and development .

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