ÇUKUROVA UNIVERSITY
INSTITUTE OF NATURAL AND APPLIED SCIENCES

MSc THESIS

Ehsan Mohammed Ibrahim YASHAR

DETERMINATION OF THE HEART BEATS ON SINGLE ARM ECG SIGNALS BY USING COMPUTATIONAL METHODS

DEPARTMENT OF COMPUTER ENGINEERING

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We certify that the thesis titled above was reviewed and approved for the award of the degree of the Master of Science by the board of jury on 18/09/2018.

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ABSTRACT

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DETERMINATION OF THE HEART BEATS ON SINGLE ARM ECG SIGNALS BY USING COMPUTATIONAL METHODS

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The purpose of this thesis is to develop a quick and simple automated computerized method that analyzes the heart rhythm from ECG signal. The system consists of five ECG electrodes, customized hardware (ADS1298ECG FE) and MATLAB program on a computer. At first, to prepare a dataset, ECG electrodes placed on the left arm of each person. In order check the final success, we also collect dual-arm signals simultaneously by customized hardware (ADS1298ECG FE). All data from the ECG sensors are recorded on the computer. Then a MATLAB code is prepared to analyze ECG signals by inspiring literature methods. Each ECG signal in the dataset is processed with this analyzer code, and the results from left-arm are compared and commented at first with ones of dual-arm experiments and also with the values of the previous methods. Although the dataset used in the study is very small, the reached success shows that this kind of a system can be useful.

Keywords: Electrocardiography, ECG monitoring, single arm ECG, heart rate detection, biomedical signal processing.

ÖZ

YÜKSEK LİSANS TEZİ

HESAPLAMALI YÖNTEMLER KULLANILARAK TEK KOL EKG İŞARETLERİ ÜZERİNDE KALP RİTMİNİN BELİRLENMESİ

Ehsan Mohammed Ibrahim YASHAR

ÇUKUROVA ÜNİVERSİTESİ
FEN BİLİMLERİ ENSTİTÜSÜ
BİLGİSAYAR MÜHENDİSLİĞİ ANABİLİM DALI

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Jüri : Doç. Dr. Umut ORHAN
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Bu tezin amacı EKG sinyalinden kalp ritmini analiz eden hızlı ve basit bir otomatik bilgisayarlı yöntem geliştirmektir. Sistem beş EKG elektrodundan, bir bilgisayara özelleştirilmiş bir donanımdan (ADS1298ECG FE) ve MATLAB programından oluşur. İlk önce, bir veri seti hazırlamak için, her bir kişinin sol koluna yerleştirilmiş EKG elektrotları. Başarılı kontrol sonuçları için, aynı zamanda özelleştirilmiş donanım (ADS1298ECG FE) ile eşzamanlı olarak çift kol sinyalleri topluyoruz. EKG sensörlerinden gelen tüm veriler bilgisayara kaydedilir. Ardından, literatür yöntemlerini kullanarak EKG sinyallerini analiz etmek için bir MATLAB kodu hazırlanır. Veri kümesindeki her EKG sinyali, bu analizör koduyla işlenir ve sol koldan elde edilen sonuçlar, ilk olarak çift kol deneyleri ve önceki yöntemlerin değerleri ile karşılaştırılır ve yorumlanır. Araştırmada kullanılan veri kümesi çok küçük olmasına rağmen, ulaşılan başarı bu tür bir sistemin faydalı olabileceğini göstermektedir.

Anahtar Kelimeler: EKG, giyilebilir cihaz, EKG izleme, Kalp hızı, Elektrokardiyografi. Giyilebilir EKG, kardiyovasküler.

EXTENDED ABSTRACT

Heart rate is the most important fundamental in the human body because the heart's function is a signal of life, heartbeat is a cardiac cycle which is the series sequence of physical and electrical that repeat in the heart every time. The heart disseminates oxygen and nutrient-rich blood throughout the body. When it is not functioning correctly, it will affect functions of other organs. Heart rate is essential to this process because the function of the heart (Cardiac output) is directly related to the heart rate and stroke volume. Furthermore, also is taken into consideration as a priority factor to earlier predictions of the majority human body diseases especially in the heart issues, for instance, the abnormal in the heart rate could reveal the problems in the blood pressure, cardiovascular, heart failure, heart arrhythmias, stress, and diabetes. Apparent and lately studies show an increase in many cardiovascular disease cause of death around the world. The Lethal arrhythmias (sudden death) responsible for 50% of the deaths at the hospitals and outpatients. The heath term word is a very major revolution now cause its clarified a guideline to the healthy life. All human drew older with life and more illness, ill range intention crucial lead to continually check the health body activities. The doctors acknowledge to analyses the body four times per year thus to identify any earlier problem in the body. As the reason for the bad manners in life conventional and poor diet and the none training, which is consequently the factor of forthcoming heart complication, blood pressure, and by the heartbeat rate measurement guide it can identify the obstacle earlier. Nevertheless, in the present days more occupies requirements and going to the hospital regularly for analyses consider as fatigued.Thereby revolutions of electronic companies proceed to innovate portable heath wearing devices namely smartwatches to investigating and inspect the person's health. totally to predict and avert the issues of the heart obstacle primarily demand to observe the vital signals. As well as document the heart beat regularly.

One of the best methods to acquire health information is from an electrocardiogram (ECG). Through an ECG distinctive such as the person's heartbeat, heart conditions, and heart disease can be analysed. Unfortunately, the most accessible healthcare devices do not offer clinical data such as info regarding patient's heart activities. Many researchers have tried to resolve this matter by designing wearable heart monitoring system with a chest strap, but their performances were not feasible for practical applications. Consequently, this study in this thesis aims to build a new system monitor heart activity through ECG signals. The proposed system consists of customised hardware (ADS1298ECG FE), platform development kit made by Texas instrument which contained two boards, first is MMB0 which is a motherboard platform to control various data converters and communicate to/from the PC. Second board ADS1298ECG is 24-bit, analog-to-digital converters (ADCs), both boards designed to evaluate the ECG signals. The kit is suitable for CCS ports and can be programmed. Moreover, the board already have software factory preprogrammed to collect the data. Thus, the ADS1298ECG platform is a significant manifestation of biomedical signal conquest and analog to digital conversion. In this study the electro heart signal measure from the four healthy person ages between 26 to 40 years old. ECG electrodes placed on the left arm of each person. Moreover the study collect dual-arm signals simultaneously to check the final success; the electrodes arrangement on the left arm of the persons. There are five electrodes sensors in this study, and they are divided into two channels, the first channel is the double arm measurement, and that represented by the negative yellow sensor on the right arm and positive red sensor on the left arm (which this also known as Lead I). The second channel is also consisting of two electrodes sensors negative and positive, along with the ground electrode sensor all on the left arm. Moreover, all the data collected by the software build by the same platform development kit then transform the data to our program in MATLAB. But the challenging signal lead arrangement suggests for weak signal arm ECG procurement instead of the chest electrodes placement. A MATLAB code distinguishes and enhances the acquired weak signal by applying four methods: continuous wavelet transform, Optimum scale for continuous wavelet transform, Correlation Coefficient and Modal Assurance Criterion.

The continuous wavelet transform (CWT) In mathematics is an official proper tool that provides an overcomplete representation of a signal by letting the interpretation and scale parameter of the wavelets vary continuously. The Continuous Wavelet Transform (CWT) is utilized to decompose a signal into wavelets. While the Fourier Transform decomposes a signal into infinite length sines and cosines, effectively losing all time-localization information, the Continuous Wavelet Transform basis functions are scaled and shifted versions of the time-localized mother wavelet. The Continuous Wavelet Transform is used to construct a time-frequency representation of a signal that offers very good time and frequency localization. The Continuous Wavelet Transform is an excellent tool for mapping the changing properties of non-stationary signals. The Continuous Wavelet Transform method in this study thesis, depends on the two main parameters named wave function and wave scale. Numerous studies extract the R-peaks from the ECG signal using Daubechies 3 (db3) wavelet function (Gordan and Reiz, 2005) due to the similarity in the shape of the signal with the heat beat signal, and by compare the wavelet function (Daubechies 3) along with the raw signal. The wavelet coefficient obtained, as get higher its mean the correlation between the wavelet function and raw signal is major and outcome will be the heart beat.

Finding the optimum scale for continuous wavelet transform wavelet method will apply to the signal with Different scale factor (in this study the selected scales between 1 and 60) and the coefficients for each scale will store in a matrix. The row and column of this matrix represent the coefficient for each scale and sample respectively. Then, the index and value of the maximum coefficient for each column will store in separate vectors. After that, the vector of the maximum coefficient values will plot and the peaks of the plot will obtain. Later, from the index of the obtained peaks will evaluate. The index refers to the scales which show maximum separation between the R-peaks and the rest of data.

A correlation coefficient is a numerical measure of some type of correlation, which concept a statistical relationship between two variables. The variables often called a sample or two components of a multivariate random variable data. The correlation coefficient values in a range from −1 to +1, where +1 indicates the strongest possible agreement and −1 the strongest possible disagreement. The correlation coefficient in this thesis is using the model of single ECG heartbeat selected as a reference data, to compare it with the similar data size (window size) along of the raw signal. Then, the window shifts in time to scan the entire signal and generate a correlation coefficient related with each window. The correlation coefficients, show a good separation between the R-Peaks and the rest of the signal, which significantly helps in detect the beat rate. This method essentially shows how the continuous wavelet methods work. However, the compared wave shapes in the wavelet method is limited to specific shapes according to the tool package but herein the wave customize according to the requirement.

The modal assurance criteria exercised in the area of experimental and analytical structural dynamics. The Modal Assurance Criterion is a statistical indicator that is most sensitive to large differences and relatively insensitive to small differences in the mode shapes. This is excellent for a good statistic indicator and a degree of consistency between mode shapes. The modal assurance criteria are often used to pair modes shapes derived from analytical models with those obtained experimentally. The modal assurance criteria limits between 0 and 1, with 1 indicating fully consistent mode shapes. It can only indicate consistency and does not indicate validity or orthogonality. On the other hand, the value near 0 indicates that the modes are not consistent. The Modal Assurance Criterion in this thesis is using the pair modes shapes derived from selected reference data of the single ECG heartbeat, to compare it along the raw signal. Then Modal Assurance Criterion coefficient generates, However, the coefficients in The Modal Assurance Criterion are between 0 and 1 according to the similarity is the shapes. Where 1 indicates to the perfect matches between two vectors and value near 0 refers to not consistent between vectors.

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LIST OF SYMBOLS AND ABBREVIATIONS

ECG	: Electrocardiogram.
SA	: Sinoatrial node.
RA	: Right atrium.
LA	: Left atrium.
IVS	: Interventricular septum.
RBB	: Right bundle branch.
LBB	: Left bundle branch.
aVR	: Augmented electrocardiographic leads right arm.
aVL	: Augmented electrocardiographic leads left arm.
aVF	: Augmented electrocardiographic leads left foot.
ADC	: Analog to digital converter.
x(t)	: Sample array of time domain data.
t	: time steps.
F	: Frequency.
N	: Sample number.
T	: Sampling interval.
Fs	: Sample rate.
f_{max}	: Maximum frequency component required of the analog signal to sample.
$X(f)$	: Original spectrum.
$X_s(f)$	: Sample signal spectrum.
a	: Scale factor parameter.
τ	: Translation factor.
Ψ(t)	: analyze function.
$\boldsymbol{\varphi}_{\mathbf{A}}$	: Single heart beat model.
$\boldsymbol{\varphi}_{\mathbf{X}}$	: Raw measured signal.
^{T}	: Refers to matrix transpose.

XIX

1. INTRODUCTION

The heart rate measurement is the most essential nowadays because it is lead to indicator the person’s health. Furthermore, it is considered as a primary factor to earlier predictions of the majority human body diseases especially the heart, for instance, the abnormal heart rate could reveal the problems in the blood pressure, cardiovascular, heart failure, heart arrhythmias, stress, and diabetes. Apparent studies show an increase in some cardiovascular disease cause of death around the world (Go et al., 2014). Lethal arrhythmias (sudden death) responsible for 50% of the deaths at the hospitals and outpatients (Eikki et al., 2001). The heath term word is a very major revolution now cause its clarified a guideline to the healthy life. Human drew older with life and more illness, ill range intention (Yalamanchili et al., 2009) crucial lead to continually check the health body activities. Doctors acknowledge to analyses body four times per year thus to identify any earlier problem in the body (Grilo et al., 2005). Since the poor manners in life conventional (poor diet, none training) which is consequently the factor of forthcoming heart complication, blood pressure and its guidance to identify the obstacle earlier. Nevertheless, the present days are more occupies requirements and going to the hospital regularly for analyses consider as fatigued (Khairy et al., 2014). Thereby revolutions of electronic companies proceed to innovate portable heath wearing devices namely smartwatches to investigating and inspect the person’s health (January et al., 2014). Overall to predict and avert the issues of heart obstacle primarily demand to observe vital signals. As well as document the heartbeat regularly (Choices, 2015).

Firstly, let's know about heartbeat (Fallis, 2013), it is a cardiac cycle which is the series sequence of physical and electrical that repeat in the heart every time. Moreover, principle concept of the statute rest of the diastole and shrinkage systole. Since human heart comprises four activating muscle chamber includes an atrial extension, ventricular shrinking, and ventricular extension. The heartbeat or rate (is the number times heart is shrinking or beat in per minute) term clarified the frequency of the cardiac cycle (Cheng, 2015). Hence heartrate is fundamentally essential vital sign in the human body. Also, the contrast in the speed of heartbeat can clarify due to physical activities of the person or health issue or disease. For example, the quit or rest heart rate illustrate as a sign of person's comfortable, also Heart definitely as a muscular mass in the mediate of the chest. Heart's primacy profession is supple continuously the blood with the oxygen and nutrients to the whole body. Suitable measurement of blood can supply the body with its need. Example of, the person in case of startled or frighten the brain naturally instruct to releases adrenaline (hormone). Thus, heart considerably beats faster and usage of oxygen rescue or face the possible risk. To obtain the person's heart is usually beating, Table 1.1 shows the fundamental measure heart rate in rest mode according to the NIH (United National Institutes of Health) that announced the list of average heart rates.

Table 1.1. heart rate according to NIH

Standard Heart rate (BPM)	Age
70 to 190	One month
80 to 160	1 to 11 months
80 to 130	1 to 2 years
80 to 125	3 to 4 years
75 to 120	5 to 6 years
70 to 115	7 to 9 years
60 to 110	Over ten years

In Table 1.1, the heart rate ratio registers slowly as person's ageing to puberty, notice that the standard heart rate (rest case) of puberty person and includes the age 10 are between 60 to 110 bpm (beats per minute). Although the heart rate can change as results of exercise and body temperature or emotional and body position and lifestyle too (Opthof, 2000).

2. HEARTBEAT AND ELECTROCARDIOGRAM

2.1. Electrocardiogram (ECG)

The term concept of electrocardiogram (ECG) clarify study to estimate the function of the myocardial electrical activity signal and muscle heart activities in shape and form of a wave, and that can access by taking the record from the surface of the heart by the electrode sensors. Illustrated analyse the hearts electrical activity clarified both contraction and relaxation state. It is essential to comprehend the meaning of terms depolarisation, repolarisation, and conduction pathway. Thus the total myocardial activity and the recounting of the electrocardiogram (ECG) can explain in more preferable.

The heart muscle (myocardium) contain cardiac muscle fibres, thus in the first stage, the electrical activity generate the impulse in the myocardium and this process call depolarisation, the depolarisation dawn at the atrium and then disseminate to the comprehensive of the heart and end up at the apex. Consequently, the total processing represents the contraction.

Second stage process starts after the depolarisation of the heart, the muscle of the heart will clam (relax). Hence its call the Repolarization. The entire fibre muscle will calm after the activity. This fundamental is the preparation for next depolarisation, the concept of the total procedure reveals the heart activity.

So, every depolarisation processer in the heart’s muscle fibre is track by repolarisation, and that generated continuous process. Emerge impulse of the heart begins at the SA node in atria and then spreads to the entire heart till apex of the heart.

Moreover, heart consists of four-chambered, their functions is to pump blood, primary stage activity of the pumping operates at the ventricles, where the atria are directly clarified as antechambers to store the blood. As a result, this process calls diastole. Similarly, the oppositive operation is when the heart will contracts the blood in chambers to the arteries and this process call as systole. As consequence of entire both operation, output obtains result come as a smooth rhythmic, harmonious heartbeat.

2.1.1. The normal cardiac cycle

The average cardiac cycle commences (Webster, 1995). Begins from the sinoatrial node (SA), where a part of specialised muscle tissue that based on the high right of the atrium (RA) in Figure 2.1. The electrical activity generates then dissemination over the (RA) and crosswise inter-atrial septum to the left atrium (LA). Atria are detached from the ventricles by inefficient electrically fibrous ring muscle. Thus the single itinerary for the electrical signal depolarisation is from the heart's atria to the ventricles over the atrioventricular (AV) node. Hence the electrical signal will postponement brief for a millisecond of time in the (AV) node. Then the depolarisation of the electrical signal disseminates downward of the interventricular septum (IVS) (Fukuta and Little, 2008), via the bundle its capable of the trend to the right and the left bundle branches, as well as to the right (RV), left (LV) ventricles. Consequently, generate both ventricles contracts conformably together. So this whole operation role a fundamental, crucial role in enormous the cardiac efficiency (Loftis, 2010).

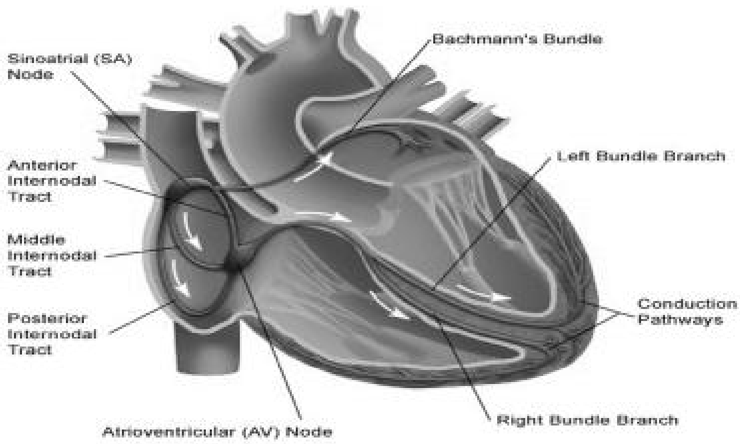

Figure 2.1. The electrical system of the Heart

So moreover to clarify the abstract of the entire processer. The impulse generates at the sinoatrial node (SA) within the atria, thus allows the extent to the Atrioventricular node (AV) then to the bundle of hiss, and Figure 2.1. Also shows on to the right and left bundle branches were it is disseminated acrosswise the ventricles see, this process goes under the name of conduction pathway.

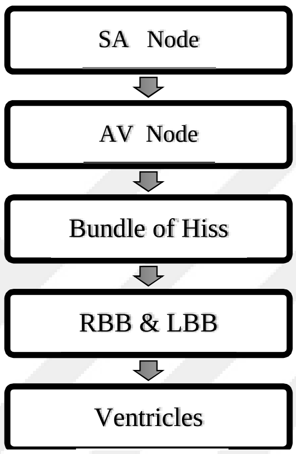

Figure 2.2. General Conduction pathway in the heart.

The term concept of the conduction pathway of any heart considers being usual, as the first impulse pursues the steps in Figure 2.2. And if the conduction pathway reversal its direction then its abnormal pathway which reveals some problem conduction. Lots of studies and experience have done through the history to discover and understand the benefit of the heart activities in future of the medical field

2.1.2. History of ECG

The ECG discovery initiated with Augustus Desire Waller, the British Physiologist, studied medicine in 1887 when he used the Capillary Electrometer (A device to indicate a slight dash electric current, were invented by Gabriel Lippmann 1873) to record his initial electrocardiogram. As so he produces the first factual Electrocardiogram device, often he practices his experience on his dog (Jimmy) for proofs and demonstrations. Although Waller did not think his discovery experience can take a significant beneficial role in the future of the healthcare because the heart’s electrical activity was simple and the devices measuring were very weighty.

Waller’s primary measurement method for human electrocardiogram presume of five electrodes points placement, four are extremities, and the fifth point is the mouth. As a consequence, he achieves to extract Electrocardiograms with low fitly contact resistance after Willem Einthoven’s discovery. The Dutch physiologist has the significant step in development and improve, invent the fundamental of the electrocardiogram also he implements his experience with the Capillary Electrometer to record Electrocardiogram. Also, he has the essential virtue technology application of the string galvanometer also known by the Einthoven Galvanometer (Plonsey and Barr, 2007). As a result, the very premiere electrocardiogram waveform present to the scientists and physician to study and analyse the hidden contents information in shape of a waveform.

2.1.3. The ECG waveform

Typically, electrocardiogram waveform consists of critical numbers of sinusoids wave, Figure 2.3 shows these forms are clarified and analyse into five different information which is (P, Q, R, S, and T) and they evidently as following:

- P wave: the active sequel function of the right and left atria means the operation of the upper chambers of the heart. Moreover, the valve between atria and ventricles opens, and 70% of the blood flows to the atria with the assist of the gravity (Naït-Ali, 2009). The critical fundamental reason for absorption done by the ventricles was the atria shrink’s need only 30% of muscle strength. Thus lead to use a small amount of muscle mass which relatively means consumption of a small amount of voltage to implement the atria shrink. So the amplitude is usually lower than 300 micro voltage and time duration is less than 0.120s, and its frequency verifies between 10 to 15 Hz.

- The QRS Complex: so, after the P wave the next thing that follows is a flat line for a short period due to the stimulus delay in a bundle to allow the atria to have enough time to supply the whole blood to the ventricles. As the ventricles fill with blood and that lead to growth in the pressure. Which cause to close the valves between the atria and ventricles. At the exact time, the electrical passes through the stimulus from bundle to bundle branches through the fibres. So the amount of the electrical creates here record as complex of three waveforms called as QRS Complex (Kaur, 2013). As a result, this procedure requires much voltage to make the ventricular muscle to shrink and create this noticeable waveform, duration may vary from the 0.070 to the 0.110 sec, and its amplitude is about three mill voltage, and these waveforms are often used to detect a heartbeat.
- ST segment: a tiny little brief period generate between the end of the QRS complex and initiate of the T wave, it is the way to detect the indicator for both myocardial ischemia and necrosis in case if it goes up or down.
- T wave: it is the lowest waveform due to the ventricular polarisation when both the ventricles repolarise before the cycle repeats itself. Therefore, T wave is visible cause it is representing the ventricular repolarization.

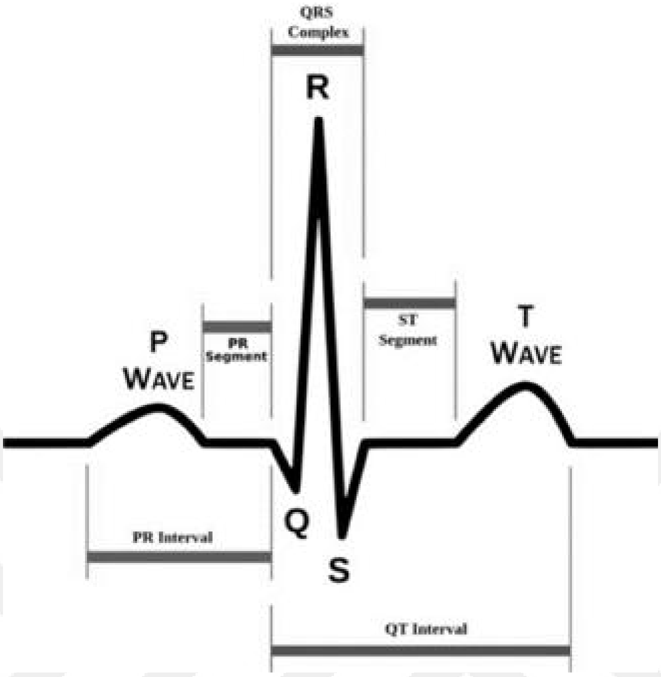

Figure 2.3. ECG wave fundamentals.

2.2. Electrocardiogram measurement

Generally, the electrocardiograms are register and measure from the superficial of the skin; the processor is by replace two electrodes precisely on the skin and find the potential read different between them. So, its achievable since the signals (electrical signals) are covey over the body (Vieau and Iaizzo, 2015). The obtain features of the signal does not rely only on the amount of the cardiac tissue quantity but also rely on the direction of the electrodes in the dipole process in the heart. By the means, the electrocardiogram measurement varies and depends on the electrodes placed on the body. Regularly the electrocardiogram measurement can use a different number of electrodes placement or arrangements. There are many different arrangements like Einthoven limb and Augmented limb lead.

2.2.1. The Einthoven Limb

The most frequent adoption locations of lead positions nowadays rely on the Einthoven Limb which is the concept of lead I, II, and III. Thus, for the intent of defining the locations of these leads, assume the torso of the human body as an equilateral triangle. It is also known as Einthoven's triangle. Due to the placement of the electrodes at the vertex of the triangle (Klein, 2016). Also, Figure 2.4 shows the measurement of the electrocardiograms in the leads placement (lead I, II, or III) listed along the same side of the triangle adopting the electrode at either end. Since every electrode uses one single electrode on both sides of the heart (Leads I, II, and III are also known as bipolar leads). As it clarifies the minus and plus signs, reveals the polarity of every leads measurements and mainly recognised as a universal convention.

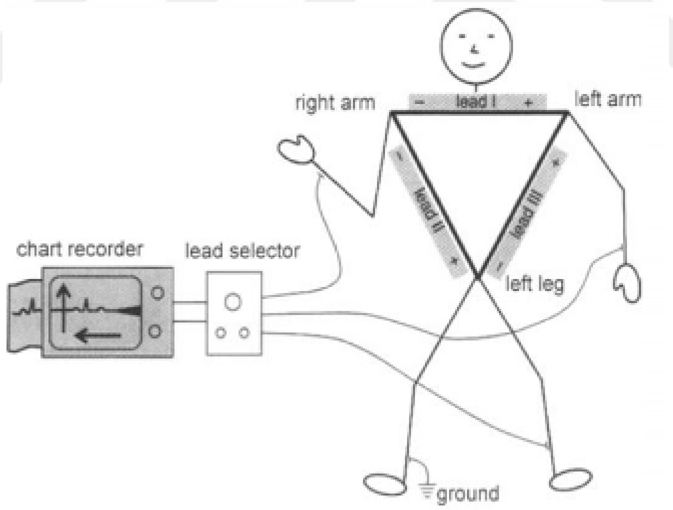

Figure 2.4. Einthoven Limb.

Take the lead II ECG signal, for example; it shows an upward deviation, consequently its clear that the voltage measurement at the bottom summit of the triangle (left leg) is extra positive than the measurement voltage at the upper right summit of the triangle (right arm). And this expresses that time point of the signal produced from the (SA) node which also known as P wave.

Estimate the direction of the heart's electrical signal shown in Figure 2.5, obtained by the atria which lead to generate a dipole descend to the left side of the body. Therefore its present as an arrow with magnitude and direction. Hence the dipole generates an extra further positive voltage on the left ankle electrode placement then the right wrist electrode placement. As a result, its produce a positive wave aberration (P wave) on the lead II ECG measurement.

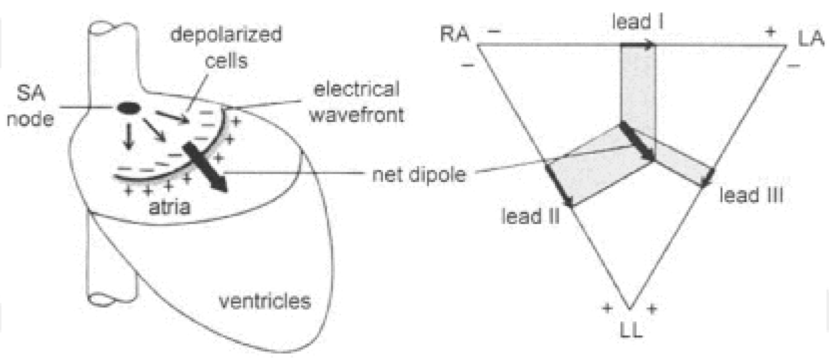

Figure 2.5. Net Dipole appearing in the Heart.

The other lead placement electrical dipole can visualise clarify from three different orientational: lead I the top, lead II to lower right side of the body, and lastly the lead III the lower left side all of them view the heart from the frontal scale. Figure 2.5 shows the atrial depolarisation generate a dipole. So the obtained result gives a positive aberration for three leads because of the arrow's overthrow on all the leads. Thus the positive terminals of the dipole pointed more to the positive terminal ends lead rather than the negative terminal ends.

2.2.2. The Electrical Axis of the heart

So overall the dipole direction and magnitude of the heart at any moment is know also as an electrical axis, due to its production of the vector in the center of the Einthoven's triangle and that direction of the vector of the dipole can be consistently estimated in degrees.

The agreement here is to use a horizontal line crosswise the top shape of the Einthoven's triangle, and that makes an angle of 0 degrees then move downward clockwise to the positive direction. Notes the path of the electrical axis changes and varies during overall the process cardiac cycle. Figure 2.6 shows the different parts of the hearts depolarise and repolarise in varies directions. The dipole dissemination through the heart at the general process of the cardiac cycle (Image et al., n.d.), set from the atrial depolarisation. Every chart in the diagram is identical to deflections at each electrocardiogram lead (I, II And III), and notes that, at the specific instant points.

The electrical axis of the heart can and may be opposite deflections on the different electrocardiogram (ECG) leads Figure 2.6 shows the heart depolarization initiates from the sinoatrial node (the right part of the atrium) thus the P wave result. Then the descent of the depolarise pass to the left, by the ventricles, a little delay set at the atrioventricular node early set of the ventricles depolarise. The depolarization in ventricles typically materialise at septum's left side, thus generate the dipole meagre downward and to the right. As a result, its produce a negative aberration of the Q waveform for both I and II while its positive in III lead.

Then the Depolarization dissemination downward to the ventricles to the apex, overall the enormous of all tissue mass will depolarise at the exact time and the same direction. Consequently, extract a significant positive aberration of R wave for all the leads (I, II and III).forword the ventricular depolarisation go on dissemination across the cardiac wall and then finish at the left ventricular side wall. Positive aberration show in both lead I and II, while the lead III reveals a lower R waveform amplitude included with negative S waveform. After the process of the continuous depolarised span, the ventricles start to repolarise. This process happens in the opposite orientation of depolarisation inspect of notes that the arrows the electrical axis for the heart and doesn't mean to show the orientation of the repolarisation wave. Because of the wave movement from the epicardium to endocardium (the same orientation of the repolarisation process), dipole remained in the same direction, same as in the path of the depolarisation. Hence appreciate why the T wave is also positive waveform on the both I and II leads and negative on the lead III. The signal returns to its standard mainline potential by the repolarised of the ventricles. All the cardiac cycle process, the electrical axis in the heart varies in both direction and magnitude. The value average of the all electrical axis vectors results to raise the mean electrical axis for the heart. Frequently one is to take the average of the dipole trend within QRS complex, because it is the highest and coincide waveform in the signal.

Generally, to obtain the mean electrical axis, calculations are done under the form of QRS complexes, and at least two leads are required. Though Figure 2.7 shows the most regular method to determine it, is by assessment using the aberration (positive or negative) and the amplitude (height) of R wave. Obtain an easy method to find the electrical axis of the heart from both the leads of I, II. And that leads to another method to detect the electrocardiogram signals called Augmented limb leads.

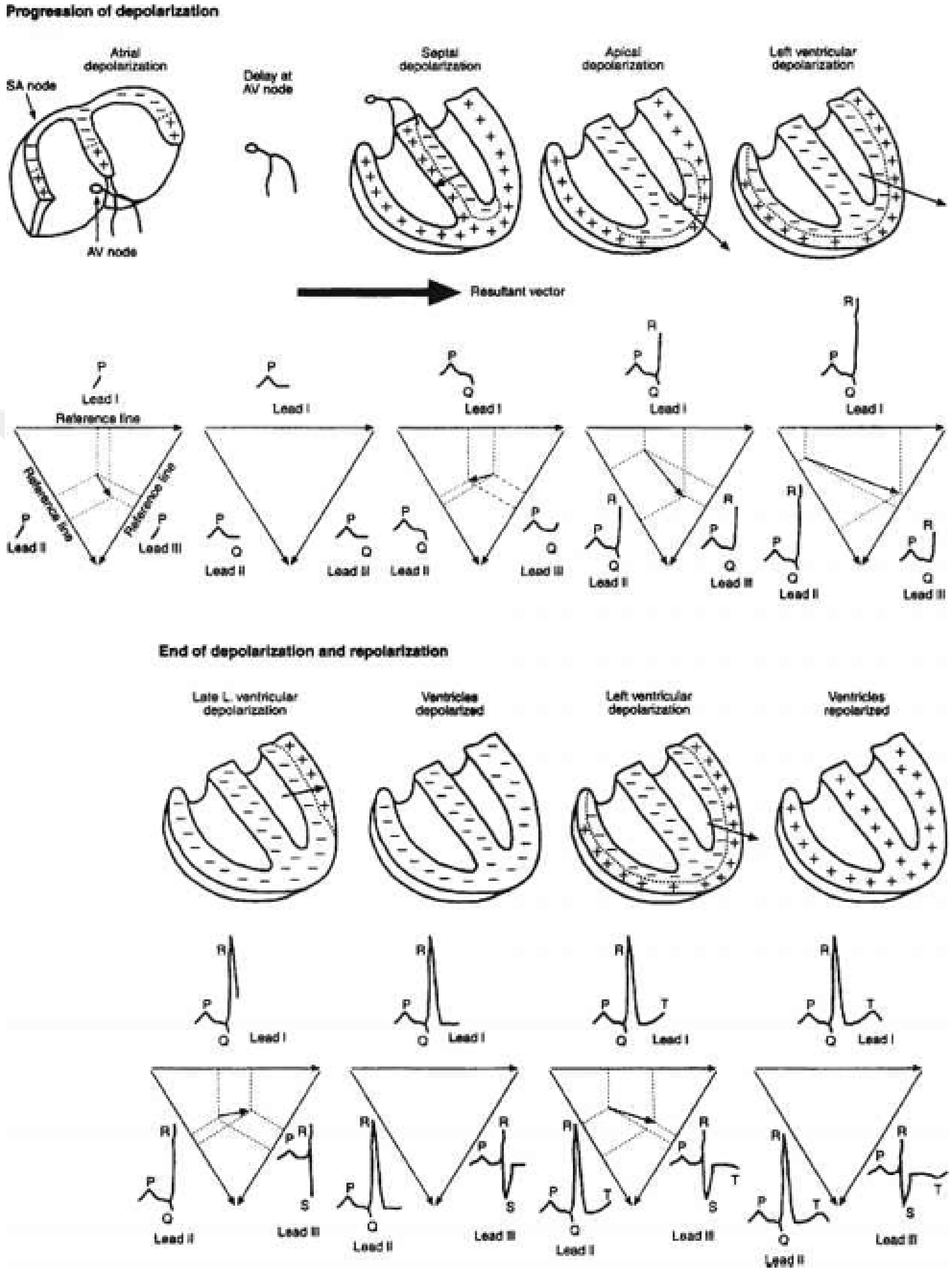

Figure 2.6. Vectors of cardiac depolarization.

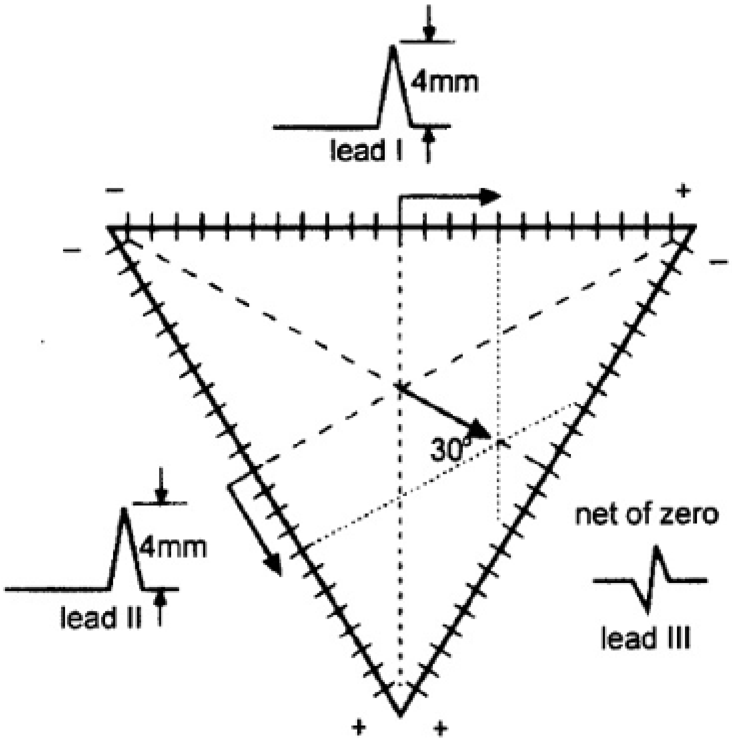

Figure 2.7. Electrical axis of the heart from the lead I and II.

2.2.3. Augmented Unipolar limb lead

In addition to the Einthoven leads (three bipolar limb leads), there are augment limb lead method which promises to obtain more active signal then the Einthoven Leads(Vieau and Iaizzo, 2015), thought the concept measurement of two connect limbs and then put them against the other limb. The reason for this terms is unipolar leads which is a single positive electrode that points out verses to set the other electrodes limb. In the augmented leads Figure 2.8 shows the positive electrodes placements are on the right arm (aVR), the left arm (aVL), and the left leg (aVF). Three augmented leads are pictorial.

At the – 30 the (aVL) is proportional to the lead I axis, at – 150 is the (aVR), and at the + 90 is the (aVF). Thus, with the standard bipolar limb leads, its include a six limb leads for ECG measurement. All six-lead measured signal electrical activity of the heart along a signal flat, description as the frontal plane proportional to the heart. As a result, the axial indication system beside the six leads able to express the orientation in the frontal level for the vector form of the electrical at any time. If the dissemination of the depolarisation from right to left with the 0-degree axis, thus lead I reveal with dominant positive amplitude. If the orientation of the vector electrical depolarisation is towards the downwards + 90 degree, the (aVF) appears with greatest positive aberration. If the direction of the depolarisation is from left to right at the + 150 degrees, the (aVL) result appeared with great negative aberration.

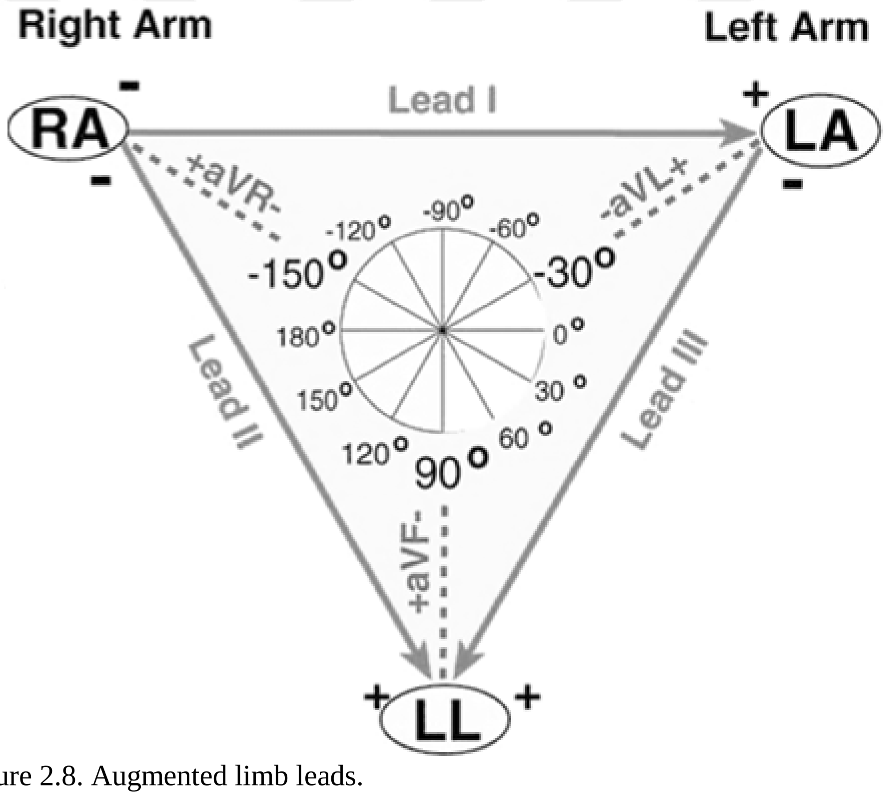

Figure 2.8. Augmented limb leads.

2.2.4. Six chest leads

The six chest leads besides the standard limb leads and the augmented limb leads. Clarify the heart electrical fundamental function from the frontal plane view. Figure 2.9 shows another six unipolar chest leads arranged and place as six positive electrodes on transverse or horizontal plane view for the heart (over the surface of the chest) in varies districts of the heart to record the electrical activity of the heart in the horizontal plane.

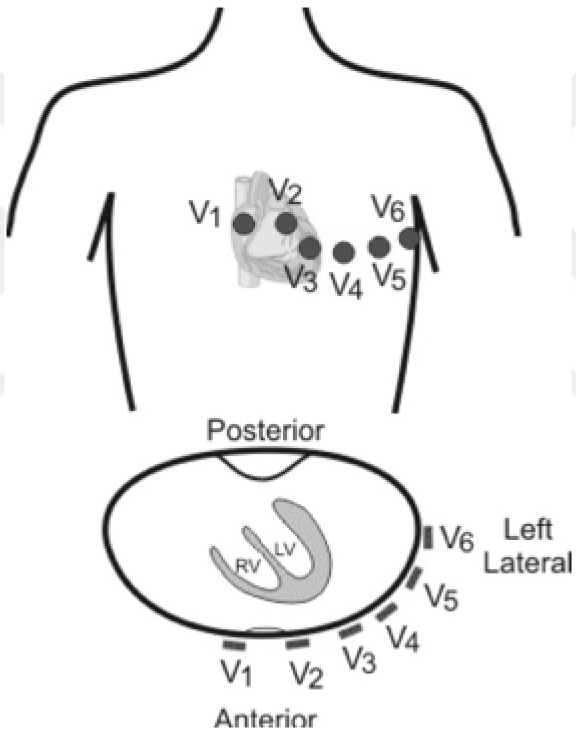

Figure 2.9 Six Chest Leads.

Six leads from the V1 to the V6 are the identical explanation to the limb leads.

So, for instance, the depolarization signal that is extracted and obtained from the specific electrodes on the chest surface is a positive aberration.

The following (table 2.1) the chest leads:

Table 2.1. Chest Leads

Leads	Ventricular locations
V_1 - V_2	ANTEROSEPTAL
V_3 - V_4	ANTEROSEPTAL
V_5 - V_6	ANTEROSEPTAL

Where ANTEROSEPTAL is a medical word defines as the position in the front of the septum, particularly interventricular septum.

As the initial ventricular depolarisation process spread from left to right and through the septum, consequently obtains first R waveform in the V1 pursue by the S waveform, since the frontal and the side walls of the left ventricle depolarise. Both of the V5 and V6 reveals large positive QRS complex. Because of both leads are overlooking on the anterolateral wall of left ventricle. Due to the enormous muscle mass subject to depolarisation (the anatomic of the heart showed that left ventricle wall is 2.5 to 3.0 times thicker than the right ventricular wall (Troy et al., 1972),(Dr. Thonthon Daimei et al., 2014). Then after it follows by the V5 and V6 leads which they are nearly the adverse in the polarity of V1. Since they check the opposite sides of the heart. Finally, the average extract result gained from the electrode placement of the V2 and V4 leads.

2.2.5. The ECG 12 standard leads

The standard 12 electrocardiograms perceive as the full heart’s electrical activity, and they are consist of (Association, 2010):

The first six leads are considered as limb leads since they place the electrodes on the arms and legs of the person. The limb leads are lead (I, II, and III), and the Augmented limbs (aVL), (aVR) and (aVF).

The second six leads are the precordial leads (six chest leads), a place on the body's torso (precordium). Six chest leads are (V1, V2, V3, V4, V5, and V6.) To measurement, the heart activity more accurately Figure 2.10 shows the 12 lead ECG; Table 2.2 shows the ten electrodes are enough to obtain the full accurately of 12 leads list.

Table 2.2. 12 lead ECG

Electrode placement		
NO	Electrode	Placement
1	V1	4th intercostals space to the right of the sternum.
2	V2	4th intercostals space to the left of the sternum.
3	V3	Midway between V2 and V3
4	V4	5th intercostals space at the midclavicular line
5	V5	The anterior auxiliary line at the same level as V4
6	V6	The midaxillary line at the same level as V4 and V5
7	RL	Anywhere above the ankle and below the torso
8	RA	Anywhere between the shoulder and elbow
9	LL	Anywhere above the ankle and below the torso
10	LA	Anywhere between the shoulder and the elbow

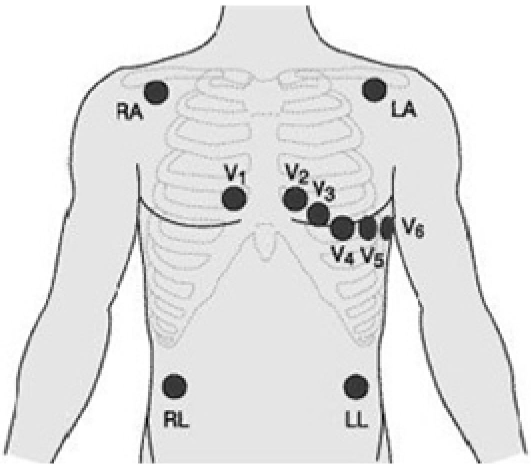

Figure 2.10. The standard 12 leads electrodes placement.

2.3. ECG Devices

The ECG device is attained to clarify and recognise the electrical signal of the heart activities, therefore to print out the info and the dataset on the paper Figure 2.11 shows the paper that made up of drawing squares (each squared has 1mm). Electrical signal impulse forms the shape of a wave. Hence the many patterns expand to become one connected wave; a standard ECG is printed on the 25 mm per second (25 small square per second), as a result of its identity to calculate the duration of individual wave ten small vertical squares, is equal to the one millivolt. Moreover, when the drawing wave line is a flat line at any moment on the recording paper that identifies that there is no electrical activity at that particular moment.

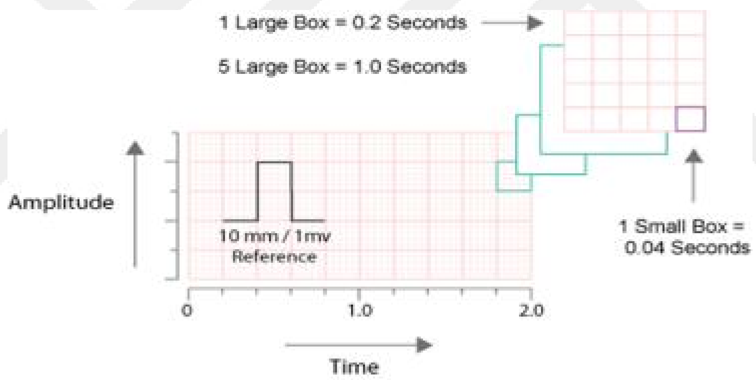

Figure 2.11. Wave line drawing.

Normal duration times defined by three terms: P-R interval, QRS width and Q – T interval.

Recording on paper recognised in 3 terms in the system of analysing the cardiac cycle, for principal and accuracy result in the terms should complete within an individual period referred as usual. Despite these measurements in fractions of seconds, ECG papers recording obtained the possible to count (time with Small Square on the paper).

The first term is known as (P-R interval), and the measurement starts from the launched from the first start of P wave to the beginning of the QRS wave, And The amount of the measurement should be 0.12-0.20 seconds or 3-5 small squares in the paper.

The second term measurement is the width of the QRS which should be less than three small squares or less than 0.12 seconds.

- P-R interval = 0.12 – 0.20 sec (3 - 5 small squares)
- QRS width = 0.08 – 0.12 sec (2 – 3 small squares)
- Q – T interval = 0.35 – 0.43 sec

So, the regularity measurement can be check by the measuring the (P – P interval) or the (R – R interval). By placing the edge of a piece of the paper along the line of the beat and mark the center of the two repeated (P waves), match up this measurement with next 2P waves if the measurements are same. Then the beat is regular. There are 300 large squares per minute, so if the beat is regular count the number of the large squares between two QRS complexes and divide the 300 on the number of large count squares.

To ensure is it sinus tempo or not need to be able to identify key features.

- There have to be always a P wave.
- The P wave should be a curved shape.
- Each P wave should be the same form.
- Each P wave should follow by a QRS.
- The P-R interval should be 3-5 small squares and constant.
- The beat should be ordinary.

3. RELATED WORKS

The field of ECG (electrocardiogram) has so many critical applications in health and safe life living and get an early diagnosis for heart disease and the Cardiovascular disease, and to improve the accuracy of diagnosing the illness and quickly and so on. Therefore numerous of studies have been done on ECG field to improve and perform better. Most of these studies focused on electrocardiogram (ECG) measurement on the body. In this section, we summarise studies based on ECG terms.

Seppo Saynajakangas proposer study in 1986 make a processor for measuring the heart beat or the ECG in specific suitable part of the body and transmitted it to another separate receiver and all that data transform is carried out using the magnetic closeness filed, by controlling magnet coils in the transmitter unit with the ECG signal detected in the body and amplified, the magnetic produce from the magnet coil and the detecting on the other side the receiver receive the magnetic field which is the same amount of produce from the ECG and the translate to be readable, This method of the discovery mainly describes the way to measure telemetric data transfer takes by using a magnetic proximity field produced in the transmitter unit and with the controlling of the magnetic coils which used the heartbeat ECG signal which generates in the person body and enlarge and amplified and on the other hand, the detecting receiver interpreted multidimensional magnetic field that comes from a coil structure and that has at least partly an identical multidimensional magnetic field directional pattern from the first part. (Siiyniijiikangas, 1986)

James Welch., Farzin Guilak., Steven D. Baker studies aimed in 2004 aimed in entirely on a wearable ECG smart sensor for long-term monitoring the patients who are at dangerous risk of life-threatening cardiac arrhythmia case, the sensor can be useful in practically any direction and part of the upper left quadrant of the chest and monitors patient health regularly for up to three days. An establish microcontroller deem the heart rate and watches the ECG signal for any heart beats with an irregular or abnormal rhythm, and that information will be transmitted wirelessly to a central server, and the testing this on human body explain signal amplitude that coming from the closely-spaced smart sensor electrodes to be the best from classic limb lead placement preparatory results set forth that innovations let in response to make design constraints for a minimal, low power lose sensor are in fact responsible for improving its performance in the aspect of noise (Welch et al., 2004).

M. Hannula, H. Hinkula, and J. Jauhiainen studies in 2008 was to develop and measure the electrocardiogram (ECG), and the ECG measurement is done by two electrodes linked to the left arm of the person's arm. The measurement of the system taken from the wrist and upper arm by electrodes and this connection goes to an amplifier which further connected via data gain or collection card on a laptop computer so in the computer the ECG signal will read and analyzes, filtered, In the application of computer a particular solution to amplifier and analysis software was structure to be able and make possible to measure and explain the very weak and noisy of ECG signal produced from the electrodes. The measurement system estimated by comparing the heart rate interval data calculated from the new ECG measurement system to Polar S810i heart rate meter and Biopac M35 measurement system, the results showed that the new ECG measurement system yielded equal results compared to the reference measurements for the situation of rest. For the moving case, the accuracy of the new measurement system reduced due to artifacts the precept procedure of the one arm electrode that based to measure ECG signal developed in this study, The short rating of the system reference that produced system works okay resemble the reference systems because of the innovative and straightforward one-arm electrode arrangement the system has a high chance to develop and improve to better accuracy as near future. (Hannula et al., 2008)

Yoo, Jerald Yan, Long Lee, Seulki Kim, Hyejung Yoo, Hoi-Jun, work studies in 2009 on wearable electrocardiogram (ECG) conquest, system execute with a planar-fashionable circuit board (A Wearable Fabric Cloth Computer by Planar-Fashionable Circuit Board Technique. Known as the method to manufacture circuits on the cloth, planar fashionable circuit board (P-FCB) and its present as a user I/O interface) and here its present as a shirt, its aim is to remove heavyweight and mess of the wires that been used in the traditional and use the suitable of the Holter record system and none sticky electrodes which is printed on the fabric to make it able to observe and record ECG information for a long time and period with benefit of none irritation the user skin .the ECG recording and collecting shirt takes advantage of an observation chip by using a set of electrodes linked around the body, and together the electrodes and the linkage performed by using P-FCB to boost wearability and to reduce the cost of the system. And the feature of P-FCB electrode is shown, and the prototype hardware executes to successfully prove the suggest idea, A wearable ECG procuration device for walking case ECG observing for long-term period executed by P-FCB technology, which showed the aim of the system achievement which is a shirt with a dry P-FCB electrode with an ability to strip the bulky mess wire issues to make a relax and comfortable wearability system and no irritation skin effect to the user, therefore, make it, a very suitable system to use by a person ,The beginning system hardware was performed as successfully prove system (Yoo et al., 2009).

I.Wang,L.Liao,Y.wang determination studies in 2010 focus on the Wearable Mobile Electrocardiogram Monitoring System (WMEMS) and it majorly contains wearable Electrocardiogram (ECG) earning device and mobile phone with universal, international system, and a healthcare server was advanced in study and most of the detection and remote diagnosis systems for long-term ECG monitoring depends on the application of communication techniques, Although the monitor for long-term ECG state is more well comfortably and relax in daily life is also a matter the serious problem, so study invent unfamiliar dry foam electrode which intended and applied to wearable ECG gaining device in WMEMS, and these dry foam electrodes without needing to gels can provide good accessibility and conductivity to earn and gain ECG signal efficiently, and can adjust to the various skin surface to preserve low skin-electrode resistance and reduce motion artifacts by the movement. Thus, the wearable ECG gainer device is appropriate for long-term ECG monitoring in daily life, Furthermore, by the merge, integrate with wireless telecommunication technique, our WMEMS can observe patient's heart rate continuously anywhere if they are under the concealment of GSM cellular network. The test results display that WMEMS indeed supply a good system prototype for ECG remote connection applications. The offer here is a wearable mobile electrocardiogram observing system for long-term ECG. The wearable ECG gain, earning device which united with dry foam electrodes and the ECG gainer module intended for long-term ECG observing in daily life and furthermore the ECG gainer module is small-volume, wireless and low-power exhaustion (long-term ECG observation its last over 33 hours), and by this wearable ECG recording device, the patients able to observe ECG states more relax and comfortable way in daily life. Moreover, on the other hand, its SMS communication technology and the patients able to share their monitor ECG anywhere in the globe if they are under the concealment of GSM cellular network. Moreover, lastly, the wearable mobile electrocardiogram observing system is also tested for patients with atrial fibrillation in China Medical University Hospital, Taiwan. For 25 AF patients, the sensitivity and positive oracular value of the system were 94.56 % and 99.22 % respectively hence the WMEMS system can be dynamic, functional, observe the ECG, and indeed supply a perfect system prototype for telemedicine applications (Wang et al., 2010).

K. Mankodiya, Y. Ali Hassan, S. Vogt, H. Gehring, U. G. Hofmann, work made in 2010 on a dry and washable tex-tile electrode establish in a relaxing outfit wearable on the chest belt, and it has been confirmed very actively for a long-term ECG monitoring in comparison to the traditional electrodes ways, So the wearable ECG chest belt outfit which includes stitched web electrodes for ECG expose and analog preprocessing circuits embedded and establish into tiny mobile phone plugs.

Consequences of web textile electrodes along with hardware establish a better transfer of the ECG signal excellence having a clinical value and enabled long-term ECG recording The study showed a successful application of a wearable single channel ECG Belt for a long-term monitoring and ECG recording with the web dress electrode belt which resemble to the traditional electrode in terms of their ability to perform and measure and record for long-term The web belt electrode has shown a promising conclusion by offer low skin-electrode noise impedance and a high SNR (Signal-to-noise ratio) for long-term recording which connected to the ECG detection cell phone, The ECG data transport from the web Belt to a remote computer Thus, the web Belt create a long-term ECG recording in patient's daily life and helps in the future by analysis and remote doctors to diagnose cardiovascular problems earlier (Mankodiya et al., 2010).

Youngsung Kim, Il-yeon Cho their studies In 2011 aim to design and evolution of a wearable healthcare monitoring system that uses the integrated Electrocardiogram (ECG) with the Photoplethysmography(PPG) along with the Skin Temperature and Accelerometer etc, in the design of this healthcare system which based on WBAN for covering a vast area of the body beside minimum battery power to support RF transmission in the device. In this study WBAN(wireless body area network), ZigBee (is a wireless networking standard that aimed at remote control and sensor applications which is suitable for operation in harsh radio atmospheres and in isolated locations) is used to transmit between wearable physiological devices and the personalised mobile system. So the study has developed several devices such as a wearable chest, wrist and necklace Device, so the wearable healthcare monitoring device system allows physiological data to be transmitted in wireless sensor network for Mobile network (Kim and Cho, 2011).

Hung-Chi Yang , Tsung-Fu Chien,Shang-Hao Liu,Hsuan-Han Chiang, studies aim and work in 2011 was to study the possibility to measure ECG by an FPC (flexible print circuit) attracted electrode to the arm of the person. So this study tries to use one FPC patch to calculate and measure ECG signal from a single arm. Moreover, the measuring of the system and software was made to read and translate the very weak and distortion and noisy ECG signals from the attracting electrode and then try to compare the result to the traditional three-point electrode measurement signal and the result showed that the new calculated signal of ECG measurement from this study have the similar and good reading to the traditional measurement when the person is in the rest position. So the new study and measuring of ECG by a circular FPC (flexible print circuit) electrode to the arm of the person, the FPC electrode construction is straightforward, and manufacture is very simple. There is benefit of this electrode it has able of well flexible that can tight attach on the skin and the measuring of the electrodes on the upper arm is more efficient and the wrong side the measurement on the lower arm cannot work well the reason of this is that strength of ECG signal for the lower arm is barely noticeable and so weak and so easy to interfered and noised by EMG (Yang et al., 2011).

J. Penders, M. Altini, J. van de Molengraft, I. Romero, F. Yazicioglu and C. Van Hoof, studies in 2011, they made to get low-power wireless ECG stand. That system is counting on the ultra-low-power ASIC for ECG read-out (is the way to get enough low energy and power and built-in to be compatible for long-term wearable for monitoring and control the cardiovascular disease and be the best application under the regular size of the battery and life power constraints.) it algorithm detects the beat almost the best effect for accuracy in a walking case which the stand or system is unified in a necklace which makes it very merely used and more relief and in same time make it more elasticity rather than the standard method of electrodes that used traditionally, this study has become fulfilled and last up to 6 days depending on a 175mAh Li-ion battery. Its performance and reliability estimated in two experimental studies. For the discovery the epileptic seizure and monitoring of Atrial Fibrillation, so the low energy power usage wireless ECG necklace is proved that is a Simultaneous observing of 1-lead ECG in the terms and steps of beat-to-beat heart rate and rev, Its supply the form of the idea of the applications can prototyped, Power usage ranges from the battery is 1.2 mA when raw data flow wirelessly, to 2.7 mA at the moment of immediate heart rate and breathing rates are calculated topically, and all information and the data saved on SD card on the device, and that approve that it can last from 2.5 to 6 days using a 175mAh Li-ion battery and that is very good to read, and analysis ECG and that is using for discovering the epileptic seizure depending on the heart-rate varies beat and observing the of Atrial Fibrillation. Moreover, these test studies explain the chance to realize the ability of ECG monitoring today using the necklace, and also refers to the possible progressing, and in the near Future expansion will concentrate on the development of motion artifact by lowering algorithms, confirming by ultra-low-power circuits and unified with light-weight spot and wearable in the same time (Penders et al., 2011).

Peter Sam Raj, Dimitrios Hatzinakos proper of their studies in 2012 focuses on the anatomy the probability of obtaining electrocardiogram (ECG) signal from single-arm by using the single-lead method and the signal of ECG the get from the signal-arm used and analyses in a biometric recognition investigation system to make sure of the effectiveness of a person’s similarity database that collected by old tradition method, the signal is collected from 23 subjects in three scenarios and performance of the proposed plan is rated, looked low Equal Error Rate of 4.34% is obtained using the described method (which is combing of the preprocessing stages tuned to the characteristics for ECG from the single arm.), establishing the utility of these signals filters electrocardiogram (ECG) signal. The chance of single-arm single lead ECG measurement has been studied and established. The signals gained from 23 persons and a system based on the AC/LDA algorithm (Autocorrelation/Linear Discriminant Analysis (AC/LDA) method) tuned to Single-Arm ECG signals applied for the performance analysis, An Equal Error Rate (EER) of 4.34% resulted found out in the ‘standing’ case while encouraging EERs of 8.17% and 10.56% were obtained from the ‘sitting’ and ‘sitting after-exercise’ cases respectively. Far from Future work in this method for ECG measurement should be focused on the big or a more massive database using a single arm and single lead electrodes to account for higher variability in large-scale deployment cases. (Peter Sam Raj, 2012).

Mitra, Urbashi Emken, B Adar Lee, Sangwon Li, Ming California, Southern works made in 2012 on a wearable ECG sensor is, and sensor system complex of the suitable wireless protocol for data telecommunication with ECG data signal understand and conversion, processing The ANT protocol (extra-low-power use and short-range wireless technology prepared for sensor networks and similar applications) applied as a low-data-rate wireless metre to decrease the power exhaustion and dimension of the sensor, moreover the method of capacitive ECG sensing is an easy technique that evades direct connect with the skin and supply utmost suitability to be usefulsmall capacitive electrodes were inserted inside of the cotton T-shirt simultaneously beside the signal processing and transporting board both of them criterion printed circuit board resolve technology. The whole system is minimal size and shape with light weight also low power usage equal to the standard tradition ECG monitoring which needs much more power usage, at the same time its suitable signal case and processing performed to cancel the motion artifacts and the result of the gained ECG signals are similar to ones that are recorded using traditional glued electrodes and are quickly read and explain by a doctors, Analyzing in the master board with the software engineering was used to supply extra signal processing and noise deletion and for the presenting the ECG data signal on the computer screen although it's tiny in size and lightweight and excellent type result of the measured signal, its belief that this sensor is a good filter for long-term ubiquitous ECG monitoring and the far future improvements can contain making the capacitive electrodes more suitable by using elastic electrode PCBs (fluffy board made of fiberglass, composite epoxy, or other laminate material) or take off the battery and supply the power wirelessly to moreover and reduce the size of the sensor. Furthermore, the signal processing on the master board that detects significant exception could also assist in reducing power exhaustion and rising the battery usage to 24 to 48 hours (Mitra et al., 2012).

Suave Lobodzinski, S.Laks, Michael M studies in 2012, made on the Holter monitors which approve to display the condition that happened in the heartbeat which is the infrequent or abnormal harmony which may happen rarely or down the certain circumstances, the future progressing in the sticky electronic technologies have become to the evolution of the first-decent wearable 14-day spot to wear for the long term of ECG recording and observing that linked immediately to the skin and demand no wires connection or electrodes to start work and collection data of ECG information, and that new inventing is inappreciable to the patients and offers them unmatched and fresh wearable and transport system and its become strongly very long-term observing of the climacteric and dangerous situation of the patients when they go to do their daily routine work or activities, and on the other hand the system is a waterproof and showed a good cohesion and sticky to the skin also it can work both cases as collection data of ECG or wireless current, flowing system, sticky ECG recorder observer present as a friendly patient-user due to its simple and easy using,and no irritation for the skin or annoying disappearing, no wires or connection stuff. PEMs' (portable emissions measurement system is basically a lightweight 'laboratory' that is used to exam or test and/or assess mobile source resurrection) it has the capability to collect the ECG data for a very permanent time which let the doctors to better embody the arrhythmic disease, no day the devices bounded to extreme of 3-leads and these still demand a cyclic standing by of the electrodes, the exclusive benefit of this study is to resolve the sensitivity and specified the data of the recording also, the possibility to define in this system is there ability to measurement art of the information that collected and extra more they have the capacity to recognize and measure QRS also able to recognize the P waveforms in the existence of disturbing noise signal for far future it expects that system will improve and the functions of the system have more precise of collecting date (Suave Lobodzinski and Laks, 2012).

Sérgio Gonçalves and Raul Carneiro Martins their studies intentions in 2013, was aim to offer a way to process and to gain and obtain the electrocardiogram in the forearm by using non-contact sensing and this new resolution should be at same time portable and wearable, comfortable relax and robust and not Irritating and become more useful in various set of applications. Considering of the system using four electrodes used in an adjustable sleeve to be wearable in the forearm, no additional electrode to use in other body parts, to increase the sensitivity of the system, a harmonium-like way used in the design of the electrodes. The primitive model then compared with a similar system with a flat modification, the developed primitive model enabled the acquisition of an ECG signal in the forearm, and the inclusion of the harmonium-like electrode modification resulted in a substantial increase of the sensitivity of the system, the obtained signal did not have and enable the symmetry of all characteristics and features of the cardiac waves. However, it was possible to identify precisely a signal pattern, characteristic and shape of the QRS complex. The properties of the gained signal are to use in active electrocardiographic studies, allowing. However, its application to use in heart rate variability control and biometric similarity without the abuse the usually connected with traditional electrodes method and that makes it useful for man-machine interfaces and automated identification. The primary purpose of objectives was the development and improvement of the dynamic so far, its inappreciable system to earn ECG biopotentials in the forearm using capacitive sensing. In order to raise the sensitivity of the system, a new design using corrugated harmonium like electrodes was suggest, so the Primitive model can measure the ECG signals, resulting in a higher SNR (Signal-to-noise ratio), gained signals did not enable their inaccurate application studies of the electric activity of the heart yet, this can applied into the ECG monitoring and biometric systems without the abuse of the usual ECG electrodes (Ag/AgCl: The electrode functions as a redox electrode and the equilibrium is between the silver metal (Ag) and its salt — silver chloride (AgCl, also called silver(I) chloride)) or even dry electrode approaches, and without request, wires to cross the body or to get undressed, and the exciting privacy we observed while making tests to the system was the capability to isolate EMG activity from each finger. This could be used for man-machine interface systems to control of prosthesis, robotic arms or gameplay control. More work will be sincere to increase the electrical surface to the physical surface ratio (Gonçalves and Martins, 2013).

Winokur, Eric S.Delano, Maggie K.Sodini, Charles Studies in 2013, intent to study on the low-power wearable, ECG recording system has entirely advanced from discrete electronic ingredient and a custom PCB (A printed circuit board). Its remove all wires and make it as comfortable to use. It is consist of five electrodes, which allows doctors to select from different projections, and tradition way method to measure ECG also take to compare it with this wearable system measurement. The data from both have recorded at the same time and upload to the Physionet viewer (is a most significant and increasing archive of the digital recordings of physiological data signals that used by the biomedical examine society and folk) and its include the WQRS detection algorithm which can sensitive QRS and extracted it from the data that were record. The system built on an elastic and usage of the power was between 2.4 and 3.33mW rely on how low or high-resolution setting use. The wearable ECG recording has a QRS sensitivity of 99.68%, and able to expect of 89.21% of positive QRS. Moreover, the results showed that is likely used to be for the wearable as daily life cardiac recording compared to wired heart and tradition way, far future design looking for modifying the power-driven and settlement during high plane of action, and enlarge the memory size which allows the device to gain the needful data for long-term ECG data and linked it to the health algorithm anatomy (Winokur et al., 2013).

W.D. Lynn, O.J. Escalona, D.J. McEneaney their studies in 2013, obtain a primary important and the remarkable matter and questions in the evolution of

ECG device measurement that is able to be taking long-term measuring and monitoring of cardiac rhythm, and to be able to use dry connecting ,nonirritant skin and long-term usage with the body for measuring and support to embedded ECG denoising processing as modern ECG databases including those provided by MIT-BIH and Physionet are focused on the translation of cardiac disease and rhythm chase. Collection data recorded by using the standard chest lead method practice, and for development and improve an environment location to track the heartbeat and rhythm monitor will be limit use To supply a beneficial database suitable for the evolution in this paper for cardiac monitoring device a signal connect body surface possibility map from the left arm and wrist was collect from 37 volunteer patients and describe in this study, Therefore the recommended electrode was placed on the wrist, and the Bipolar far-field electrogram leads were taken and analyzed. Factors such as skin variability, power line 50Hz noise interference, electrode contact noise, motion artefacts and electromyographic noise, introduce a challenge, the fundamental aim was to select quantity at signal-to-noise ratio (SNR) at the far-field locations. Elementary results expose that an electrogram indicative of the QRS complex can be recorded on the distal portion of the left arm in the case where the denoised using signal averaging techniques (Lynn et al., 2013).

Wang, Yishan Wunderlich, Ralf Heinen, Stefan aim objectives in 2013 was to introduce a wireless wearable low noise Electrocardiogram (ECG) idea using for an extended period home care keep wide observing the ECG signal from the three Leads ECG, An acquire circuit is performed to strip the dc amount component formed by the body motion and using a high common mode rejection ratio (CMRR) device amplifier to decrease electromagnetic interference (EMI). So the analog end of front side is linked to the termination of the device which models by the three Leads signals and sends information data to the arranging part on the PC using ZigBee protocol which is used to create personal area networks with tiny, minimum -power digital wireless, like home automation, medical device data gathering, the QRS and heart rate exposure algorithm performed on the GUI data (GUI is A program mediator that takes features of the computer's graphics ability to make the program merely to use, neat designed graphical user interfaces can free the person from learning complex order languages) and system is estimated when the person is walking and running. A sensible execution did even underbody motion activity. So the low noise wearable wireless ECG system which records and observe the three Leads ECG signals for extended period homecare and introduced. So lower number of the ingredient is used in this work to make the system as built-in as probable. And 50/60 Hz intervention and dc interference caused by body activity motion and electrode unidentical are gazes and reduce and cut by high CMRR INA (Common mode rejection ratio (CMRR) measures the capacity of a differential input amplifier, such as an op-amp (operational amplifier is a DC high-gain electronic voltage amplifier with a variable input and, generally, output is a single output) to refuse signals common in both inputs) and ac conjugation circuits respectively, so the low noise wearable wireless ECG system which records and observe the three Leads ECG signals for extended time period homecare and it's introduced. So lower number of the ingredient is used in this work to make the system as built-in as probable. And 50/60 Hz intervention and dc interference caused by body activity motion and electrode unidentical are gazes and reduce and cut by high CMRR INA (Common mode rejection ratio (CMRR) measures the capacity of a differential input amplifier, such as an op-amp (operational amplifier is a DC high-gain electronic voltage amplifier with a variable input and, generally, output is a single output) to refuse signals common in both inputs) and ac conjugation circuits respectively. IEEE 802.15.4/ZigBee protocol which its properties are lower power exhaustion than another protocol is used to forward the information data from finish side of the device to the arranging part on the PC. Signals through the body activity action are measured and matched with the traditional ECG measurement, so work implements amended of the abolition of body movement activity impact. Moreover, QRS complex and heart rate are as well reveal. Extreme precision also accomplished when the person is running (Wang et al., 2013).

Sameera Nanayakkara ,Lilantha Samaranayake studies in 2013 explains and describes the purpose and application of a wearable remote ECG monitoring which includes the wearable ECG device and the cell phone application to communicate with the ECG device system and the wearable device records the real-time ECG of the person's wearing of the device and connected with a remote server using the person’s own cell phone, The system record and captures ECG signal using three electrodes located inside a 5x5 cm area as wearable chest belt, the device includes an onboard Bluetooth 2.0 module to keep connected with the cell phone and the mobile phone connects to the remote server using GPRS network and the system also observe the activity of the wearable chest belt using an onboard MEMS (Micro-Electro-Mechanical Systems,) accelerometer and the algorithms to resolve and analyze the acceleration data created at different activities, the collected data are sent along with the ECG data to backing up the diagnosis procedure, the distant server includes the databases and interfaces to store save and preview the real time as well as stored data. It is looked after by the hospital interested and is confirming by the telecommunication operators. The wearable remote health situation monitoring system presented with unique awareness to the wearable and understood, notice the resulted ECG and motion know the arrhythmia (a condition in which the heart beats with an irregular) detection algorithms. Low signal to noise ratio (SNR) of this study reflects as a significant feature advantage while the device is miniaturised to establish in a 5x5 cm square, Total power exhaustion of the device is also reduced and consumes only ten mA at the routine operations and 30mA when Bluetooth transmission is going on. Moreover, as the system and device resolve, and analysing the ECG data itself and transmitting only at any exception detection makes its power exhaustion further reduced and makes it possible to run with a 200 mAh rechargeable Li-ion battery (Nanayakkara and Samaranayake, 2013).

Yu, Xinchi Boehm, Anna Neu, Wilko Venema, Boudewijn Marx, Nikolaus Leonhardt, SteffenTeichmann, Daniel aim studies in 2014 attempt to register ECG for long-term and period cause it is a severe paramount diagnostic mode in the field of cardiology, to investigate causal of the arrhythmia which means the heartbeat irregular. As it knows that the tradition way to measure ECG using viscous or sticky, electrodes which is the reason of the skin irritations to the patient's skin and also cause a disconnect in the collecting ECG data information and in the same time its try to relax and ease the treatment way, here in this study, it's advanced a wearable 12-lead ECG T-shirt with dry weaving electrode stain linked to the recording ECG device. The results show that the t-shirt cover has a significant difference data information, which is highly following on the person. By take the fact that the clinical study not able to use in different environment, but this system is entirely unified into the persons daily routine life and farther more in its use compression T-shirts to raise the connect pressure to the person, and that will get better signal quality, and the ECG T-shirt can alert a doctor if heartbeat or work break down (arrhythmia), motion artifacts do not show any severe issues, also its enough to use one, lead with a good ECG signal is sufficient. In this case, united of all leads safety increased slight chance time to get the result of ECG (Yu et al., 2014).

Jang-Ho Park, Dae-Geun Jang, Jung Wook Park and Se-Kyoung Youm studies in 2015 focuses on the sophisticated heart rate (HR) surveillance near to the same way we measure the pressure difference of the surface of the ear canal. A scissor-shaped device provided with a piezoelectric film sensor, hardware circuit module was prepared for wearability and to obtain a steady measurement, in this suggest device, the film sensor transforms in-ear pulse waves (EPW) into electrical current, and the circuit module promotes the EPW and represses and crushing noise, A real-time algorithm establish in the circuit module performs structural conversions to make the EPW more featured, particular and knowledge-based essentials are used to reveal and uncover EPW peaks. In a clinical experiment proceed using a reference electrocardiogram (ECG) device, EPW and ECG at the same time recorded from 58 healthy subjects. The EPW period between sequential peaks and it was same ECG period when they compared to each other. Hopeful the results were obtained from experience more specifically a sensibility of 97.25%, the positive predictive value of 97.17%, and mean the difference 0.62. Therefore, highly accurate HR obtained from in-ear pressure difference then it confirms the suggest oncoming could be used to observe pivotal signs and also used in varied applications within near future, The evolution of a wearable sensing device is in both highly delicate and relaxing to measure EPW. The scissor-shaped device is progressing and aid support use of a small piezoelectric sensor and measurement of in-ear pressure difference. The piezoelectric sensor was enough sensitivity to reveal the pressure waveforms from the ear canal surface. The hardware circuit module expeditiously amplified EPW and filtered diverse noises and the firm algorithm properly to revealing EPW peaks though knowledge-based rules, so the result is from all the new findings gained in this study are the following: (1) HR can be precisely revealed from the pressure difference of the ear canal surface,(2) a piezoelectric sensor can be measured as a part of a wearable sensor device as well the health study offered very hopeful results that showed that this study near close to the delicate and execute well too, so it is a method that could be used to observe HR, and may also be used and applied in varied applications in close near future example is it could be to mix with this method with a hearing aid and beside that hearing aids are already one of the most public ear aid devices earring damage and the old people, would be able to receive clear and pivotal sign and observation interest and there weren't be any known past potential to produce this manufacture, but relief in the volume and form of the device and the circuit board could supply the key for the prosperity of such a product like this (Park et al., 2015).

Zheng Gang, Han Zheng-Zhi, Dai Min propers of their study in 2015, aim to design a wearable or portable ECG (Electrocardiogram, ECG) Healthy active stand suggestion, and the platform is sharing the collected data with network, and the wearable ECG dive designed to collecting signal with features as non-sticky fabric electrodes which is so helpful to improve the comfort of user test, The wearable device is a comfortable shirt and the location of the electrode is V5 lead of clinical ECG device and its non-stick electrode instead of the traditional Ag/AgCl electrode for making it more comfortable. All parts were inserted on a shirt, and the platform like QQ (Tencent QQ is an immediate messaging software service developed by the Chinese company Tencent Holdings Limited. QQ also offers services that supply online social games, music, shopping, microblogging, movies, and group and voice chat software). Is built a database of the architecture of ECG observation, transmit, and diagnosing here its selected 16 healthy bachelor volunteer students. Moreover, it collected the ECG data and stored it, then diagnosed it by its cardiology doctors of Tianjin chest hospital. Try to test the results show that the platform is steady, reliable, and its response can be possible to use for the real-time application. The develop wearable ECG healthy monitoring stand on SNS (A social network service or social networking service, most often called SNS, is a medium for establishing social networks of people who share interests and activities). It makes the connection between the doctor and the user more accessible than ever before and improves and develop the information transport speed in a short time between the doctor and the patient. Face to sudden heart attack, and time lateness, of traditional ECG checking, is issue but with this platform supports real-time ECG it’s accessible to collecting, transferring, diagnosing, and safe information feedback is possible, and its promising to view on reducing heart attacks and the primary platform aim is the effort on heart attack early alarming. Until now the stand of this method was doing tests on small-group of people. In the next stage, the will be active in Tianjin Chest hospital for more extensive scale testing (Zheng et al., 2015).

Byungkook Jeon, Jundong Lee and Jaehong Choi their studies in 2015, is about the plan to design and perform a wearable ECG (electrocardiogram) record system with cell phones for monitoring and tracking daily life. A diagnosis person daily and distant-diagnosis for inveterate heart disease patients before the unexpected heart attack. Its shirt or smart shirt with ECG that can be dressed by the sick person or average healthy person and record the ECG daily life, doctors and professionals about heart disease can incoming the patients' data wirelessly in the real daily routine with their cell phones, this study of this smart dress or shirt can be helpful mostly for major citizens who live alone or have an inability or failure, thus this system can be used for distant medical systems to help the old patients for self-exam diagnostics and for the practitioner to diagnose diseases of the circulatory system, The study here has intended and execute a wearable ECG menstruations system and an Application for the system based on the Android OS stage so now the system can watch and record and diagnose patients' heart situation in daily life routine by using the dress as sports-shirt with a built-in ECG sensor. Moreover, bonus for that too is the application supply diagrammatic information with individual and single history administration tools and an auto emergency call system to call in the dangerous situation and far more in the future study and improvement are needed for less energy exhaustion and more precise measurements (Cho, 2015).

R. Geethika, Manjunath A E studies aim in 2015, on the Electrocardiogram (ECG) confession, admission, and observe is the only way to mark and locate and defined heart Diseases. ECG observe and with features such as portable, wireless, user-friendly, low-cost and appropriate, suitable at home, are needful, the target and purpose here are to explore the wireless Body area network communion for person activity chase and ECG information record, and believed to be the easy way to supply the patients with valuable information about healthcare and continuous observation for the health situation and far more recording the medical information at home or office will help of the physicians to periodically oversee and overlook the patient’s medical condition without need to see the patient and the imperturbable measurement information and date will be remedy using specially intended software that will aid to transform a medical data that record from the patient to an electronic device in the earner at physician. Cell phone and PC could be expressible as display and relay change stations out of the ECG signals will be transmit to the data center which is in the hospital by the network, A mobile ECG system that is permanently observation a person's heart wants only save their life by immediately calling for emergency help in the condition of heart disability and it can also protect many lives indirectly by supplying investigator for the set of data that been take for heart’s activity and make it detecte the heart disability, the algorithm summary that been progressed make it can read the data signal from a mobile ECG and execute it in two significant tasks first one is to save the collected data for the processing analysis in the laboratory after that the second task is to execute several primary active dissections on the arrived data to define if the person is proved to need a medical emergency and If this is the situation then the cell phone will take suitable action counting on the seriousness of the emergency condition (Geethika and Manjunath, 2015).

Aulia A. Iskandar, Reiner Kolla, Klaus Schilling, Wolfram Voelker their studies in 2016 focuses on the people are get more worry and anxiety on their fitness situation and as we see that the digital healthy lifestyle movement become more and more. And as we improve the developed device give us and tracker activity has given a lot of information and data about the person movement and activity in the day to fulfill their daily aim and goal to achieve of calories burned, and one of this improved tracking system can be able to measure heart rate with precise activity in excellent level but as we try to look to these fitness devices it seems they can also use for clinical diagnosis by adding the ECG measuring function to it, and by that feature, it can be a daily health monitoring or a health support and aid device by linking it to the internet via a Smartphone and to use an ECG as a wearable device, the electrode positions, and locations have to perform the clinical position. So the study introduce us to the new biomedical electrodes position which suggesting to meet the practicality of a fitness lifestyle device and in the same time it observes and monitoring continuously the heart condition in a medical way by the necklace form. And the system has a single lead ECG analog front end that is linked to the an ARM-Cortex M4 microcontroller (The Cortex-M4 processor is advanced to address digital signal control markets that request an effective easy-to-use mix of control and signal processing ability) and the system is able to 4 GB memory card and benefit of rechargeable battery and using Bluetooth with Low Energy 4.0 to communicate with an Android 4.3 Smartphone, and the device was taken from the 32 years old person with a healthy heart condition the signal gained from the electrode placement in the backside of the neck produces the Lead I waveform with 10% from the standard position amplitude value. Moreover, the R-wave can easily noticeable from the signal of the heartbeat that has been collected. Thus it is proved that can be able to monitor heart daily, so in this exploration, we reach to accomplished a design and achieve a new path in the health wearable devices by adding the activity tracking of the fitness products with the medical ECG measurement, the form of necklace shape device take the measurement of the heart electrical activity from three electrode positions on the backside of the neck and gained by a single chip single-lead analog-front-end ECG and a 200 samples/sec ADC on an ARM-Cortex M4 microcontroller with 4 GB memory card with a rechargeable battery, Low Bluetooth Energy 4.0 for linking with an Android 4.3 Smartphone. Moreover, measuring and recording the ECG signal the backside of the neck is able and possible to shift around the cardiac vector of Einthoven Triangle with even measurement distance and have the same ECG signal waveform. Thus wearable necklace device which like cube form is an ECG device which is suitable to observe the heart rate in constant and comfortable relaxing situation like seating position without head movements, and the R-wave in each single heartbeat can be clearly seen even with low amplitude value which reduced to 0.15 mV, and for this result now it is clear that it can be measuring and calculating the heart rate continuously and rightly that can be used in the daily use without using medical devices (Iskandar et al., 2016).

Haseena.P.A, R.Dharmalingam their studies in 2016, aimed benefit and how essential to get monitoring early health condition especially the electrocardiogram (ECG). Moreover, as all the ECG and its possible to get the characteristics of the person what precisely what means the heartbeats and heart conditions to discover the early heart disease to analyse it before it is too late. However, unluckily lots of the obtainable of the healthcare devices and system do not supply right clinical information and data such as information concerning patient’s heart efficiency, numerous investigators have attempted to resolve and fix this issue by the manufacturer and inventing wearable heart observation systems with a fingertip system, but their performances were not workable for actual applications Therefore the goal and the focus of this work-study is to construct a fresh and new system to observe the heart activity out of ECG signals, so the offer system includes an establish hardware in an armband, It is deemed to be a trustworthy, sturdy, and low-power-transport ECG control system, The accuracy of this system was done by the exact placement of searchlight in the fingertip. IoT is used as the protocol for data transport, a modern wearable device for a healthcare observing system was suggested in this study, and the device was performed in a fingertip to check ECG signal. The fingertip was selection as standby to past wearable devices that are a bundle to the chest and which can be uncomfortable for some persons, and the technology that has been used in this system is photonic motion, and it called as photoheliographs, and the important thing is this study to notice is bio-signal that was collected in this system is an ECG signal. Though the ECG signal that is received from the arm is minimal the offer of the system was smart enough to beat fuss, hubbub and detect reveal data and the information from the recorded signal, (Haseena.P.A, 2016).

N.Manivannan, N.Celik, W. Balachandran studies in 2016, introduce another device to record ECG signal as wireless Multiple Smart Sensor System (MSSS) in synchronism with a cell phone that able to become a hidden and small device with easy way monitoring of electrocardiogram (ear-lead ECG) and unified with multiple sensor systems which include core body temperature and blood oxygen saturation (SpO2) for patients that able to walk too, The intent and plan here is to put it behind-the-ear, and that makes it a device system that more likeable and favorite to measure ECG information and data cause it logically and technically so easy and less complicated, physically connected and attached to non-hair regions. Thus it is more suitable for long-term usage and as a person who uses it will be more comfortable to use and don't need to undress the top clothes. Moreover, the intention here for this device is the same of the smart sensor device is just like the system of hearing aid device purpose, wirelessly linked and connected to the cell phone for transport physiological data and information and show it, and also this device and the system not only gives and allows the access to the features of core temperature and ECG from the ear only but far there more this device can be planned and modify by removed and reapplied by the person or the patient himself at any time. Therefore, these features make it more and excellent benefit usability of personal healthcare applications. A numbering of collection and series ECG electrodes, where are established, placed on the area of the electrode and also test on the dry and also non-dry nature of the flat of electrodes and examined on different locations near and behind the ear and after that best ECG electrode is then picked up depending on the Signal-to-Noise Ratio (SNR) of the recorded and measured ECG signals, and the recorded that taken from the electrodes produce reasonable Signal Noise Ratio of ~20 db, and its seems to be similar to the existing tradition method of the ECG electrodes. Moreover, the Inventor of the this ECG electrode system is merged it with trade and commercially available PPG sensor (Amperor pulse oximeter) and core body temperature sensor (MLX90614) using an expert of microcontroller (Arduino UNO) and the results monitored and showed by using a newly developed cell phone (android) application, The system gains different physiological data and information and continuously and all the time monitors on the Android-based cell phone letting the patients and allow them a real-time control of data. Moreover, this device provides and consists of non- noisy sensors, specifically ECG, CBT and PPG with high accuracy. Furthermore, it can also test the Android-based app that used and try to combine the recording of all sensors and displays ECG, CBT, and SpO2 biological data on the cell phone of the user person, it also tries to watch and monitor the impact and the effect, of sensor placement and its effect on the signal quality using different types of ECG electrodes. Furthermore, it makes it easy and helps and assist the as hardness of wearable giving patients safety and less limitation by eliminating the need for adapting nosy equipment or using a laptop to see the biological data, our results clearly explain the probability and the likelihood of the idea and group work of the sensors are the solutions and the critical technologies for the scientific problems. Despite making essential progress in classifying many of the matters, there are still significant issues that need to be amended. Outlook studies will take into counting the growth to the traditional body sensors and give a new point of view for the refinement of the design of the particular ECG electrodes to minimise noisy data according to the motion artefacts. So, the study paper of the ECG electrode method is explaining to catch up the ECG information signal from the area behind the ear in comparing to the standard tradition chest founded ECG measurements, The results obtained are very hopeful and discovery of the ingredient and the components of the ECG signal (P, Q and R) which is highly possible. As it aforesaid that is the device that attaches behind the ear for ECG measurement which makes it more user-likable and gives additional suitability of using the electrodes only when it is required which means there is no need to preserve the electrodes attached all the time, and the method is straightforward which is included in uniting the ECG, PPG and co-body temperature using Arduino microcontroller with cell phone. For conversion and transformation and displaying the information and data and in the near future more test and experiments will be a layout, resolve better electrodes and significantly increased signal-to-noise ratio to get the results identical to the classic ECG signs and to explain the United systems under different operating case (Manivannan et al., 2016).

Preejith SP, Dhinesh R, Jayaraj Joseph, Mohanasankar Sivaprakasam in their studies in 2016, they aim at perfect extra-low power ECG stands for constant and minimally clear observation for systems with lower and down conversion and processing ability, capabilities, The podium is eligible of discovering and detecting exception in the ECG signal by educing, read out and resolve the features related to different cardiac trends, in this stand which built to continuously fill operate on any of the 12 leads and the offered work contain a single lead application that operates on lead I or II. A single lead, wearable ECG patch that can detect cadence-based arrhythmias and continuously monitor beat to another heart rate of the heart and the aerobic rate has been progressing. And far more the device can keep and stores net ECG waveform locally and is intended to run for 10 days on for one charge, the connected ECG spot work in synchronism with a front-end device or slab and together updates the results on the tablet interface, a top disclosure of an exception or an arrhythmia the device turnover to an ECG conception mode which enabling the manual analysis on the gained, obtained signal and also the front end device also functions as a port for remote monitoring which makes the operation and processing ability of the stand along with the effectiveness tests in a controlled setting are presented, so the device and ECG platform for continuous and real-time observation and analysis are offered that device executes and carry out natural and lightweight algorithms perfect for systems with lower and conversion processing ability. So it introduces a single lead model for this suggests device, the activity of the single lead system was proved in a controlled setting using a simulator another step in future includes a carrying out a large-scale clinical effectiveness to understand the stabilization of the algorithms and the acceptability of the suggested model in a clinical setting (Preejith et al., 2016).

Zheng, Jiewen Ha, Congying Zhang, Zhengbo studies in 2017, focusing on the daily life recording, the activity of physiological data information will supply and lead us to prudence more into the physical condition of user-patient or normal athletic and will estimate therapy wares and practice execution. The study is the small size of the wearable cardiopulmonary monitoring which called (Smart Chest Strap) that included an elastic belt dress around the user's chest with the unified of sensors physiological signals earning unit and a cell phone, the daily activities and physiological signals consist of the electrocardiogram and aerobic inherited to the plethysmograph and both are precipitation and sampled then digitalized, stocked, and lastly together inherited and transport to the cell phone through Bluetooth, A medical effectiveness test with participants performing discontinuous gradual like a treadmill (0–12 km/h) exercise was proceeded and made. The results reference nearly perfect linkage and small bias, and slim limits of approval for heart rate (HR), and a general direction of reduction in accuracy, fineness, and correlation for HR, BR as speed increases, but these healthy statistics are all within acceptable error border, the finding result showed that the Smart Chest belt is useful and will have broad applications in healthcare. So the Smart Chest belt has been advanced with sensors unified within the elastic band and the medical effectiveness exam on the 9 healthy people (all man) was executed and finding out the legitimacy and the truth of Smart Chest belt for capability for measuring HR, BR (breath rate), and ACC (measures the time that any person can take in the exercises to reach his maximum Speed) through different strength, adversity actions, but yet in the future there is the excellent field for refinement the system, by adding the skin temperature (TSK means skin temperature changes over time) which is a physiological severe factor to estimate the result and perform of the body's thermoregulation (temperature) system with the most significant help of this in illness analysis and diagnosis (like as breast cancer, which show to be connected with abnormal TSK various) the infrared TSK detecting technology establish in the system moreover, renewal is the information data translation but in condition duty of conveying recording of the daily activity of physiological signals is sufficient for a simple distance medical monitoring system, the system of the smart chest belt system capable of operating the physiological factors in status, so that is suitable returns can give to the users, such as irregular physiological case, mental pressure. For the future work as this study composed data information form significative physiological of 20 students by utilizing the Smart Chest belt as they do their routine daily activity, its notice vital attention to see the link between mental pressure and some other unique feature like heartbeat rate various and prospect to supply a workable settling for banning various illness occurs by mental stress and preserve and look after the mental issues (Zheng et al., 2017).

4. SIGNAL PROCESSING

Signal processing nowadays is performed in the senior majority of electrocardiogram system and other system fields to analysis and interpretation. The objective of the electrocardiogram signal processing is manifold and comprises the improvement of the measurement precision, and reproducibility and the obtain of information not readily available from the signal through visual estimate. Many situations, the electrocardiograms record during ambulatory or strenuous condition such that different types of noise corrupt the signal, physiological process of the body. Thus, noise reduction represents another essential thematic of signal processing; in fact, the waveform of interest is sometimes so hardly covered by the noise that their valuable information can only be revealed by applying signal processing methods and here is the basic fundamental need to know:

Let's look closely what the signal. What the team of the signal is, and try to put the whole signal and the word of the signal in an easy way to explain and understand. Consider the thing that is varying with time is signal. Another word to explain it is that is signal is anytime changing the metrical quantity, and there is lots thing in our world we can consider as signal like pressure, sound, light, temperature and of course the electricity too. Thus, most of the electrical system signal goes through the processing and analysing, which generally it notices the significant part which is the parameter (the voltage and current). The matter part considers as metrical quantity and time-varying electrical parameters, so to modify the heat, sound, and light and other parameters into the electrical energy, therefore is the transducer which is the convert here (Edition, 2006). Example for this is the microphone measures the changeable in the air pressure caused by the sound waves and transforms it into the time-varying voltage. Another example is to take a thermocouple to create the voltage at the point were two various metals joined, and it is almost relative to the temperature that measured. So, the signals divided into two parts: analog and digital.

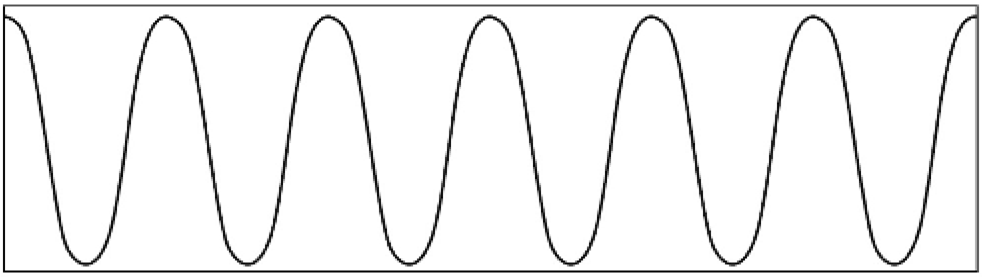

Figure 4.1 Analog signal / sinusoidal waveform

Analog term is clarified being as a signal which precisely represents the value and amount of the metrical or physical quantity or electrical synonymous then its applied to use for analysis and processing. As an example, the signal of one tone of sound can measure as sinusoidal Figure 4.1 shows the varies electrical voltage in time. Therefore, voltage value present as electrical synonymous each voltage can measure in every immediate time of the signal. Furthermore, the time-varying voltage signal can measure, and the signal referred as an infinite solution for both of the signal amplitude and the time (Smith, 1999). Thus, the output from a microphone or any sensor is mainly an analog signal.

So, the digital signal is different from the same original signal (analog signal). The digital processing form income a snapshot from the original, snapshot of the original is measure and save at constant intervals (not continuously), thus mean digital signals are discrete time signals (Tutorial Point, 2015). Let ’s have a sinusoidal signal in Figure 4.1 as an example.

$$x(t) = B\sin(3\pi F t)$$

Take a snapshot of this signal at constant time T=(1/F) second and F consider as the rate of snapshot where it took for the original signal; the t presents as T a discrete of time index n, so for Figure 4.1 signal can be produced.

$$x(nT) = B\sin(3\pi FnT)$$

Moreover, Figure 4.2 explains how the analog sinusoidal signal looks like in the form of digital signal.

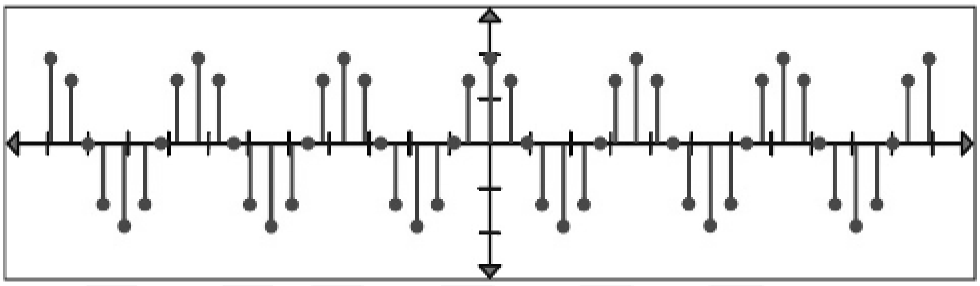

Figure 4.2. The sampled signal of the analog sinusoidal waveform (digital signal)

Moreover, the digital signal can represent simpler by considering the discrete time signal as an array in the sampling index n, represent and denoted as f (normalized frequency) so it's get to be

$$x(n) = B\sin(3\pi fn)$$

So to convert the original signal (analog signal) to digital signal the calculation and anatomy processing by the digital computers are not enough to sample the signal to the discrete intervals. The digital system represents and interconnects with data as a sequence of zeros (0s) and ones (1s). The numbers (0,1) or binary numbers well specify to each value of analog signal value rely on or count on the different factors as like (data size, microprocessor architecture or the way the software deal with the data) (Tompkins, 2000). So, as a result, it is essential that discrete time analog samples also be transformed to one set of potential discrete values too. Besides of all that, there is another important part that should notice. That part is the (system) and the system can clarify as (electrical circuits, mathematical operations or physical projects) and all that affect the signal properties and characteristics. An example for this editing the frequency contained the signal to obtain the output signals that some of the original signals frequency bands tighten more than other or to erase some specific frequency. So, whatever the signal is analog or digital the system will be analog signal processing system or digital.

4.1. Digital signal processing

So as known now about the signal. Thus let’s head and understand the concept of the digital signal processing (DSP). Digital signal processing is the kind of the technology that makes our life much more comfortable. It is impacted our lives in many ways cause without it all the internet, and digital audio, video, digital recording like MP3, cellular phones, digital cameras, TV, satellite, both wire and wireless network and even the medical devices all of that would be less proficient. Moreover, would be unable to provide the essential and useful information specifically in diagnosing area. Example if there was no digital x-rays and medical image or digital system to analysing the ECG (Electrocardiography) (Tan, 2008). Now future was hard to discover and treat the disease earlier. So if there isn’t DSP technologists and scientists and engineers were suffering and had no easy ways to analyse or imagine data or perform their designs and so forth.

Figure 4.3 digital signal processing.

So, Figure 4.3 shows digital signal processing can be clarifying in the diagram. The first step is the input of analog signal is entering the analog filter. After that to the ADC unite (Analog –to- digital converting), then to the DS (digital signal processing, and DAC unit (a digital to analog converting), lastly a reconstruction filter to gain the analog output.

First, the input signal which is analog (continuous in time and amplitude) and can take from around us like current temperature or voltage pressure and light. All that measurement can be taken by the sensors which can change the nonelectrical signal to analog electrical signal (voltage), and that part is supplying the analog filter and filter will apply on the analog signal to specify the limit frequency range for the analog signal before the sampling process. The purpose of this filter is to reduce the noise and distortion in the analog signal (Tan, 2008). After that step, the output filtered analog signal is then will sample and converted to the ADC to get the digital signal (discrete both the time and amplitude). Then digital signal gets processed in the DC unite will apply to the digital signal processing rules (band pass, low pass, high pass digital filters or different algorithms) after DS unit processor. Next, the output signal will modify depending to an algorithm used in the system. The next block which is DAC unit which changes the processed digital signal into the analog single again and the final block job is to specify as a part to smooth the DAC output level voltage back to the original level voltage in the analog signal, and that can do by reshaping filter.

To be noticed that in the standard that analog signal processing is not in need of software to process, but it is usually the processing depending on the electrical and electronic devices other meaning the resistors, transistors and operational amplifiers and capacitors, and integrated circuits (IC). Moreover, on the other side, the digital signal processing is using the software (algorithms and digital processing), hence its ability to deal with noise and interference and fix the signal distortions in various applications(Vaseghi, 2005). Moreover, it is essential that the DSP system minimum have analog processing (as anti-aliasing and reshape filter) which are essential to transforming the real-world information into a digital signal and after processing, need to change again to the analog signal to perform in the real world.

4.2. Digital Filter

In the describing the digital noise signal that obtains from the transform analog signal voltage to digital (the signal that comes out of the sensor out), have an essential and useful low-frequency signal information (Davies, 2000). However, the noise has overall the signal make it impossible to get this information cause the noise has separated in all the frequency range, as it said before the analog signal gets to the ADC unit, and the output of it will be a digital signal. Figure 4.4 shows that x(n) were then here is the sample number, so the digital filter has the important part which is the improving the signal. As the signal has significant essential and useful information is in the low frequency so that means the signal that has amplitude more, thus considered as noise and that can remove by the user of the digital low pass filter. The digital filter set to be simple digital low pass filter (Vaseghi, 2005). So after the digital noise signal x(n) enter this digital filter. The output comes clean digital signal y(n). After that, it can be used to in other digital signal processing algorithm or operation or may be transformed again to the analog signal (by the DAC unit or reshaped filter). Moreover, for a more clear picture of the entire process. Figure 4.5 presents a noisy signal in the top part (A) and the de-noised signal at the bottom part (B) or clean signal that is the result of applying the digital low pass filter.

Figure 4.4. Digital filter block

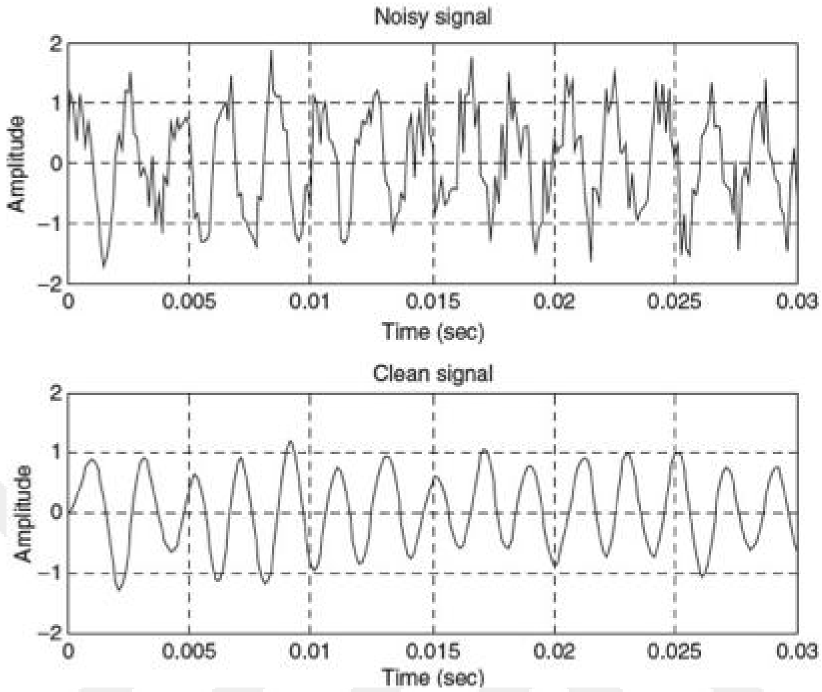

Figure 4.5. (top A) noise signal / (bottom B) De noised signal using digital low pass filter

Some of the digital signal processing application demand to the time domain and frequency contained in the signal analysing (Parker, 2013). Figure 4.6 shows digital signal beside it a signal spectrum (mean frequency content). Which can represent as signal amplitude matching frequency for a time through digital signal algorithm named fast Fourier transform. In Figure 4.6 (A) shows that a time domain signal with a frequency of 1000 Hz in the sample rate of 16000 per second. Moreover, the part (B) showed the same signal in the spectrum and calculated the spectrum signal against the frequency, where it can see the peak amplitude located at 1000 Hz. Moreover, part (C) shows time domain of the signal with the signal of 1000 Hz and 3000 Hz both sampled at 16000 per second, and the frequency of the both of the signals showed clear at part (D). Moreover, for clarity, Figure 4.7 shows the diagram processing of spectrum analysis.

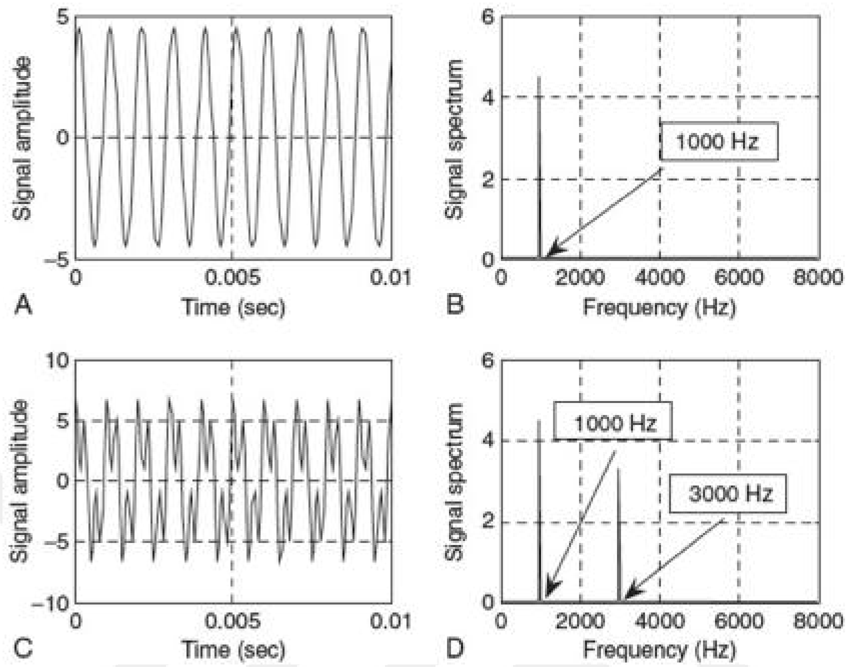

Figure 4.6. Signal and their spectrum

Figure 4.7. Spectrum analysis

4.3. How to Sampling the continuous signal

So to sampling the continuous signal into the time domain. Look at the analog signal (meaning its continuous with time) which clarify every point in the time (horizontal axis) and the amount in the vertical axis (meaning the amplitude voltage). Where in a result means that the analog signal holds an infinite point in time (Parker, 2013). Thus it is an issue to unable to transform it to the digital because it has an infinite point, so the problem is that digital processing cannot deal with infinite points the reason behind that is the request of infinite memory amount and infinite processing. Therefore the only way to solve this problem is the sampling, and the way that sampling is deal with this problem Figure 4.8 shows the way to take the simple at a constant time interval (fix time) and the time here T consider as sampling period in second (Tompkins, 2000). So, the ADC unit needs it time to convert, so Figure 4.9 shows each of the samplings contains its voltage (amplitude level start from 0 to 5 or -5) at its sampling period T and that called sample and hold.

So, for each sampling interval, there is one amplitude level (Tan, 2008). Thus can obtain and draft each amplitude level to its conforming sampling time spot. Figure 4.9 shows 14 samples are corresponding to their sampling time spot. Representing as a vertical bar with circle ball at the top of it. Were the T being identify as sampling interval, which is the extension or space between the two-sample vertical bar, hence the sampling rate is.

$$f_s = \frac{1}{T}\ Sample\ per\ second\ (Hz)$$

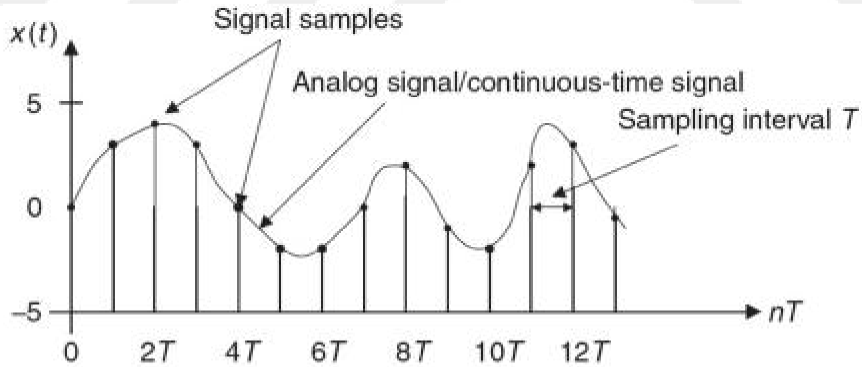

Figure 4.8. Sampling signal

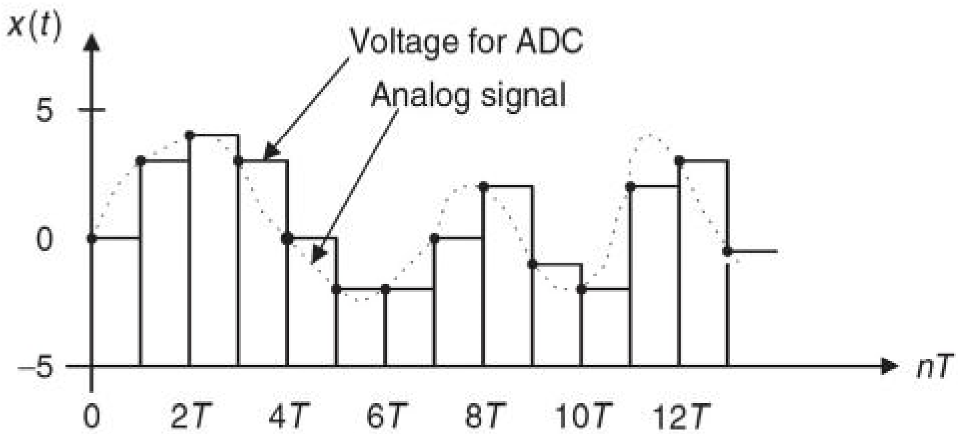

Figure 4.9. Sample and hold analog voltage.

As an example, for this case, if there are sample period 200 microseconds (meaning T), as a result, lead to determine the sample rate which is f_s= 1/200 microseconds which is equal to 5000 sample per second (Hz)(Tan, 2008). So, after the procedure of sampling the analog signal, the obtain sample signal is the amplitude values occupied at the instants od sampling, and this processor is able to handle the sample points. Next step is to make assure that samples are amassed at high average enough to make able to restoration or reconstruction the original analog signal, moreover required a minimum sampling rate to obtain a complete rebuild of the analog signal from the sampled signal (Madisetti and Madisetti, 2009). If an analog signal is not an aptly sampled distortion or an error happen, thus undesirable signals will appear in the required frequency band (Parker, 2013). The sampling theorem makes sure that analog signal can be in theory fully restored in case the sampling rate is double large the analog signal highest frequency component be sampled.

$$f_s \geq 2f_{max}$$

Where:

f_{max} : maximum frequency component required of the analog signal to sampled.

Furthermore, an example for this, take the sample of the speech signal consisted of frequencies of 4kHz with the minimum sampling rate is at least 8kHz, (8000 samples per second).

So, to expand the sampling theorem in the frequency domain, the minimum sampling rate desired for an analog signal. In general (Tan, 2008), this can be a beneficial process to resolve the anti-aliasing filter (meaning a lowpass filter which declines the high frequencies that is the reason of aliasing) to be used before the sample. Also, in the anti-image filter processing (a rebuilding lowpass filter will sleek and soft the recovered sample and grip voltage standard to an analog signal) used after the digital-to-analog transformation (DAC).

The Figure 4.10 shows the sampled signal $x_s(t)$ gained from sampling the continuous signal $x(t)$ at a sampling rate of f_s samples per second. Thus, to depict the continuous signal and the sampling pulses (pulse train) in mathematical form

$$x_s(t) = x(t)p(t) \tag{4.1}$$

Where:

$p(t)$: is the pulse train with a period ($T = 1/fs$)

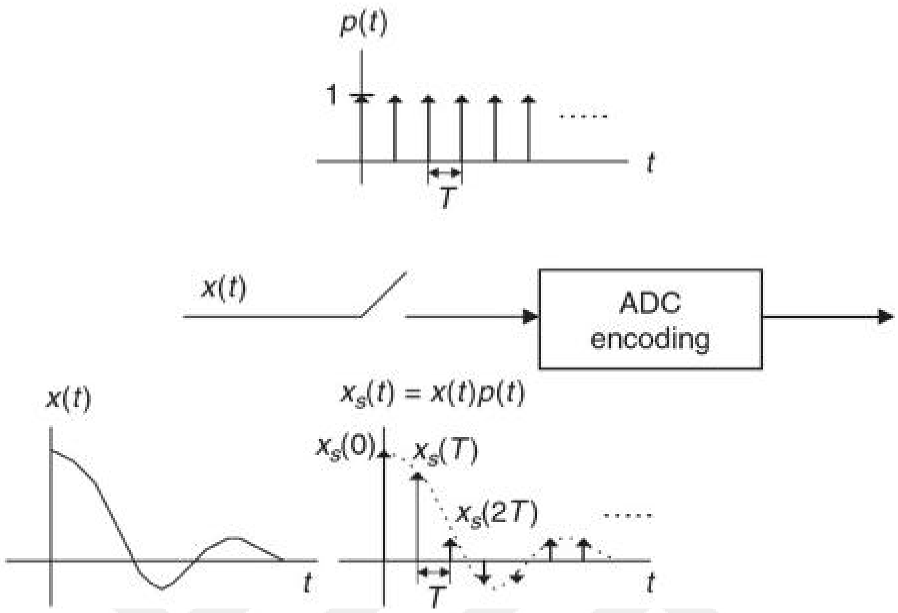

Figure 4.10. Simplified sampling process

The $X(f)$ frequency components (original spectrum) with $X_s(f)$ the sample spectrum (Hz) are related as

$$X_s(f) = \frac{1}{T} \sum_{n=-\infty}^{\infty} X(f - nf_s) \tag{4.2}$$

Where:

$X(f)$ is the original spectrum.

$X_s(f)$is the sample signal spectrum (both X(f) and its imitations $X(f \pm nf_s)$).

The dilate of the equation bring on the sampled signal spectrum in the equation below:

$$X_s(f)=\frac{1}{T} X(f + f_s) + \frac{1}{T}X(f) + \frac{1}{T}X(f - f_s) \tag{4.3}$$

Equation (4.2) references that the sampled signal spectrum consisted of the sum of the original spectrum and shifted transcript versions called replicas (Tan, 2008). Equation (4.2) present three potential drawing in Figure 4.11.

The Figure 4.11 in part (A) shows the original signal spectrum X(f), And the Figure 4.11 part (B) shows the first sampled signal spectrum in accordance of equation (4.2), the replicas $\frac{1}{T}X(f)$, $\frac{1}{T}X(f-f_s)$, $\frac{1}{T}\ X(f+f_s)$, … segregation between them. While Figure 4.11 in part (C), present baseband spectrum and replicas are linked. And the last Figure 4.11in part (D), shows the original spectrum $\frac{1}{T}X(f)$ with its replicas $\frac{1}{T}\ X(f+f_s)$, $\frac{1}{T}X(f-f_s)$, ... are interfered (Zolzer, 2008). So, the Figure 4.11 clarify the sampled signal spectrum which contains the scaled baseband spectrum in the midst of the original and its replicas midst the frequencies of $\pm\ nf_s$ (double of the sampling rate) to each n = 1,2,3, …

If implemented low pass filter to obtain an accurate restoration of the original signal spectrum the following case must do:

$$f_s - f_{max} \geq f_{max} \tag{4.4}$$

Furthermore, solving the equation (4.3).

$$f_s \geq 2f_{max} \tag{4.5}$$

Also, in the frequency (radians per second).

$$\omega_s \geq 2\ \omega_{max} \tag{4.6}$$

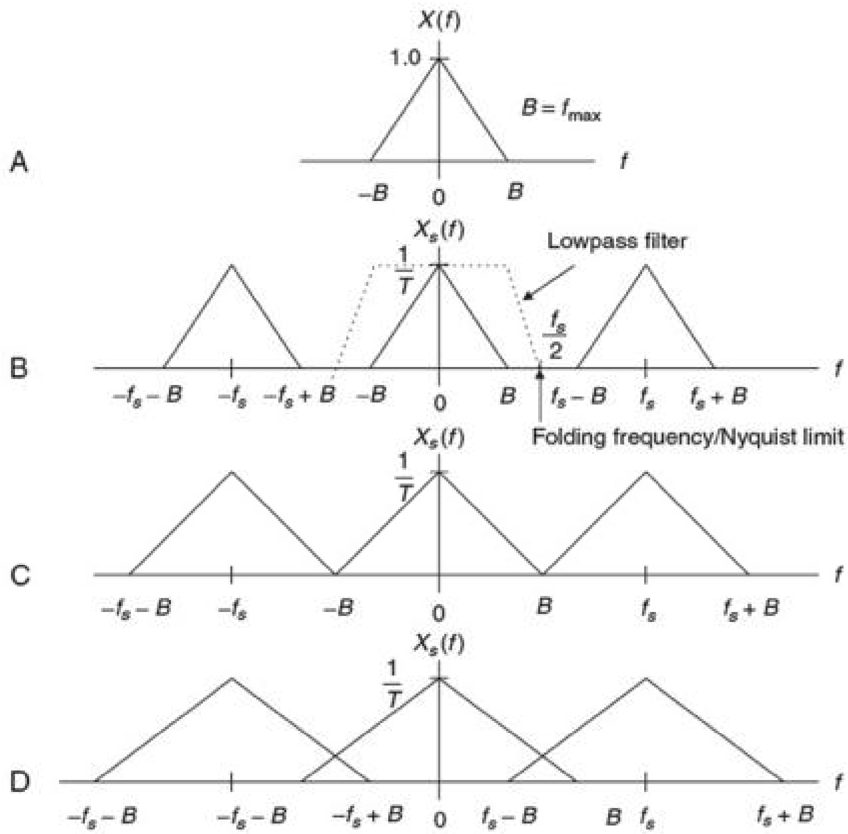

Figure 4.11. Sketch of Sampled signal spectrum, (A) original signal spectrum X(f), (B) first sampled signal spectrum, (C) baseband spectrum and replicas are linked, (D) the original spectrum.

5. MATERIAL AND METHOD

In this study, the heart rate acquisition device is base on customised hardware, which consists of two stages. The first stage is responsible for electrode sensors collect the electro heart as analog signals. While the second stage is analog to digital converter (ADC), which converts the signal to a digital form that later can analyse in digital space, i.e. in a computer. Next, the dedicated software is used to diminish the noise and determine the heart rate by applying filters.

5.1. Material

We use a platform development kit ADS1298ECG FE; Figure 5.1 shows a platform development kit made by Texas instrument which contained two boards, first is MMB0 which is a motherboard platform to control various data converters and communicate to/from the PC. Second board ADS1298ECG is 24-bit, analog-to-digital converters (ADCs), both boards designed to evaluate the ECG signals. The kit is suitable for CCS ports and can be programmed. Moreover, the board already have software factory preprogrammed to collect the data. Thus, the ADS1298ECG platform is a significant manifestation of biomedical signal conquest and analog to digital conversion.

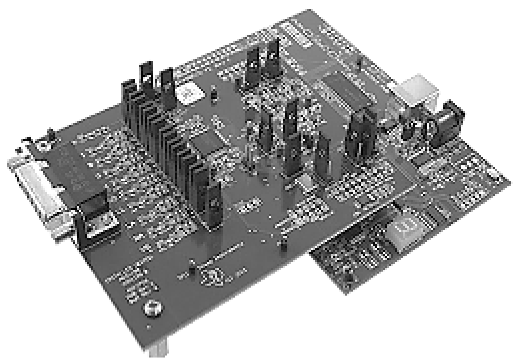

Figure 5.1. Platform development kit ADS1298ECG FE.

In this study the electro heart signal measure from the four healthy person ages between 26 to 40 years old. ECG electrodes placed on the left arm of each person. Moreover, in we also collect dual-arm signals simultaneously to check the final success, Figure 5.2 shows the electrodes arrangement on the left arm of the persons.

There are five electrodes sensors in this study, and they are divided into two channels, the first channel is the double arm measurement, and that represented by the negative yellow sensor on the right arm and positive red sensor on the left arm (which this also known as Lead I). The second channel is also consisting of two electrodes sensors negative and positive, along with the ground electrode sensor all on the left arm. Moreover, all the data collected by the software build by the same platform development kit then transform the data to our program in MATLAB.

Figure 5.2. Electrodes sensors on the signal arm lead.

5.2. Method

Diagnosing the electrocardiogram is the most powerful signal in the medical field, which provides important information about a person’s health condition. During the last years, wavelet transform has confirmed to be a valuable tool in many applications for analysis of the non-stationary, and electrocardiogram (ECG) in particular in many studies (Gautam and Kaur, 2012) (Aqil et al., 2016)

(Ghaffari et al., 2008). This thesis four methods presented: continuous wavelet transform, Scaling continuous wavelet, Correlation coefficient and Modal Assurance Criterion (MAC). So the following sections will define and clarified each method in details with result and figures.

5.2.1. Continuous Wavelet transform

The wavelet transform materialized over recent years as the most preferred solution by researchers for analyzing dubious signals across a wide variety of areas and fields such as engineering and medicine. The wavelet transform is utilized as a powerful tool for, noise reduction and extracts important features from the interference signal. It provides the efficient localization in both time and frequency (or scale). Wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution corresponding to its scale. A key feature of wavelet techniques is the variety of wavelet functions available, thus allowing the most suitable to be chosen for the signal. Furthermore, in methods based on wavelet, there are no general rules for selecting a wavelet form for a particular application (Dohare et al., 2014). The continuous wavelet transform (CWT) is a usually common used in a signal-processing for the analyzing of non-stationary signals (Gautam and Kaur, 2012). In addition, continues wavelet transform (CWT) is clarified as the sum over all time of the signal multiplied by scaled, shifted versions of the wavelet function.

$$\mathbf{C(scale\ , Position)} = \int \mathbf{f(t)\psi(scale, position, t)\ dt}$$

The outcome of the Continues wavelet transform (CWT) is wavelet coefficients C, which is a function of scale and position. Multiplying each coefficient by the suitable scaled and shifted wavelet product the constituent wavelets of the original signal f (t).

$$\mathbf{CWT(a,\tau)} = \frac{\mathbf{1}}{\sqrt{\mathbf{a}}} \int \mathbf{s(t)\psi}\left(\frac{\mathbf{t-\tau}}{\mathbf{a}}\right) \mathbf{dt}$$

Where:

a: The scale factor parameter that stretches or compresses.

τ: The translation factor that shifts the mother wavelet along the axis.

s(t): An integral signal that sum is multiplied by the translated mother wavelet.

$\psi(t)$: The mother wavelet which is the function of the scaling and translation factors.

As result figure 5.3a, 5.4a, 5.5a, 5.6a shows the raw measured signal, where the Figures 5.3b, 5.4b, 5.5b, 5.6b shows heart beat obtain after (CWT) method, Table 5.1 clarified all the heart beat result.

The continuous wavelet transform (CWT) are chosen for the following reasons:

- The discrete wavelet transform (DWT) could lose frequency resolution due to resampling at each decomposition level (Yochum et al., 2016).
- The CWT preserves a perfect frequency resolution.
- With CWT, the suitable and dominant scale for each component of ECG signal can be extracted, which makes it probable to detect each component separately (Ghaffari et al., 2008).

Table 5.1. Continuous Wavelet Transform (CWT) Result.

	Data No	(CWT)
Person 1	D1	77
	D2	78
Person 2	D3	105
	D4	105
Person 3	D5	82
	D6	83
Person 4	D7	94
	D8	93

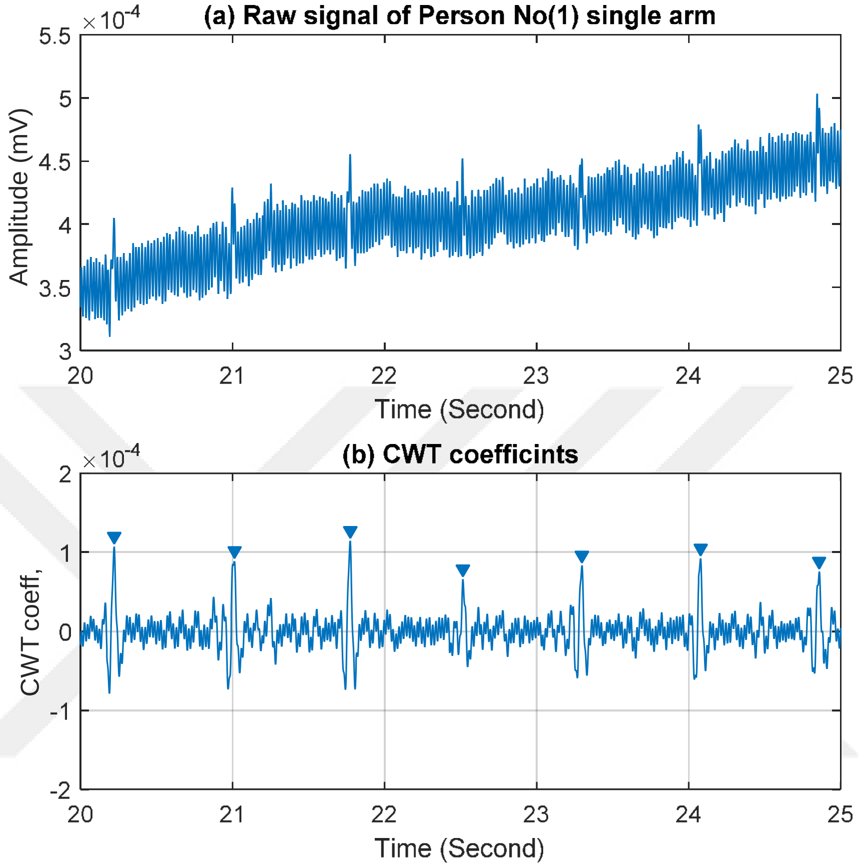

Figure 5.3. Continuous Wavelet Transform Result for single arm Person No.1.

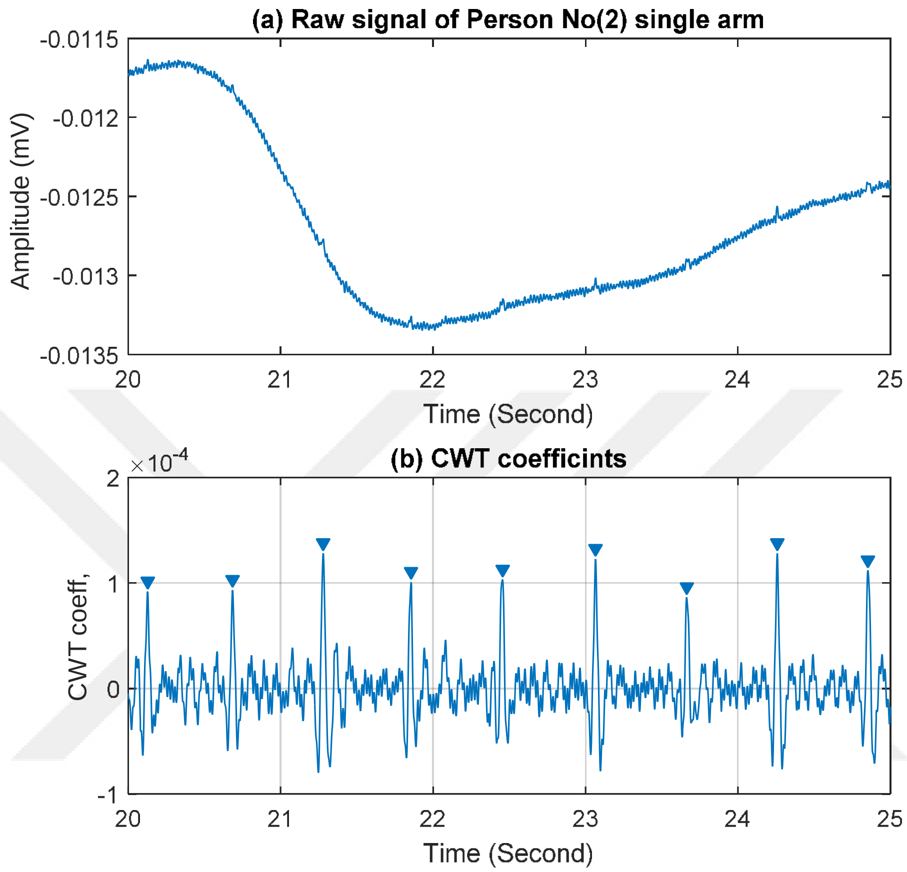

Figure 5.4. Continuous Wavelet Transform Result for single arm Person No.2.

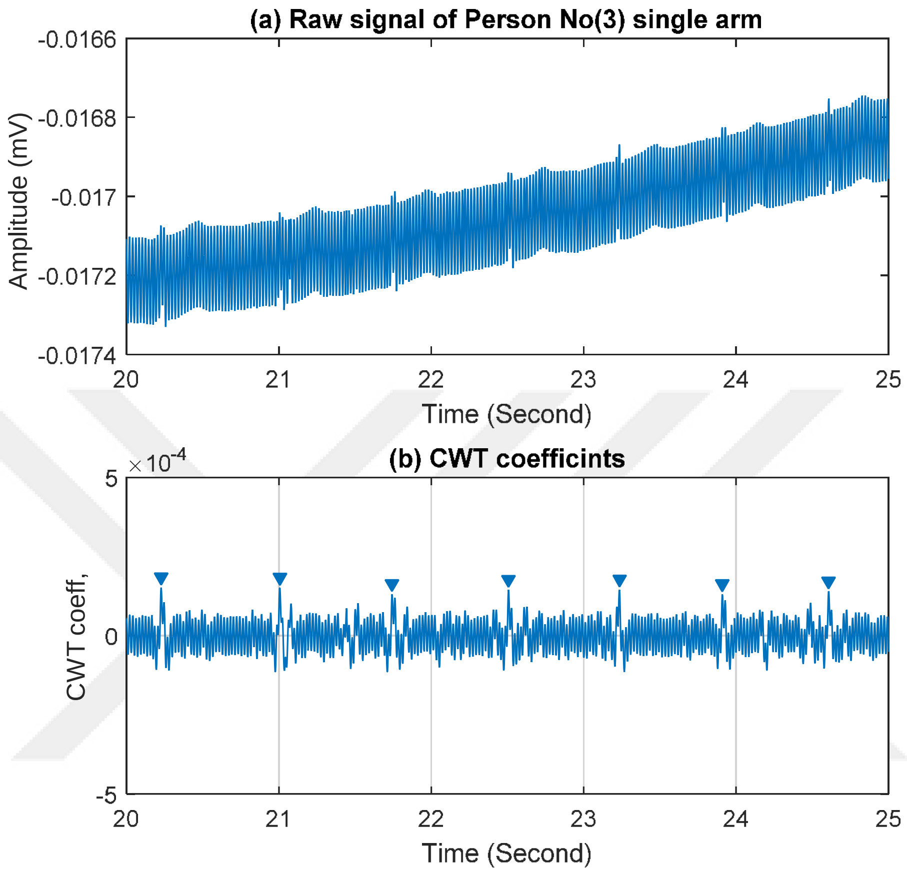

Figure 5.5. Continuous Wavelet Transform Result for single arm Person No.3.

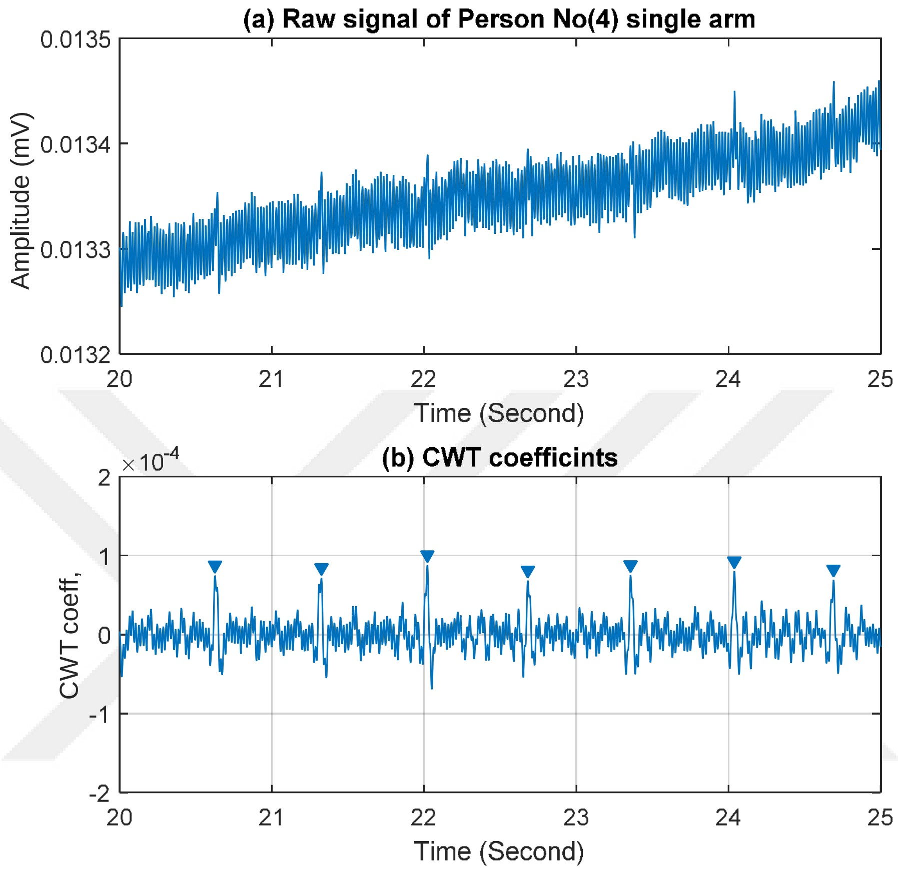

Figure 5.6. Continuous Wavelet Transform Result for single arm Person No.4.

5.2.1.1. Find peaks algorithm

In this study, the finepeaks command from the MATLAB toolbox is utilized to detect peaks during the signal processing stages. According to mathworks Inc. (Mathworks, 2007). The finepeaks algorithm works in clear steps to detect the maximum peak in the signal. The procedure starts with locating local peak by comparing the elements of the vector. Then from the local peak a straight horizontal line created to the left and right of the local peak. Now, if the horizontal lines intersect with the signal it means there is another peak higher than the first local peak and the element comparing will start to detect the new peak. In contrast, if the lines reach the ends of the signal it means the current peak is the maximum point in the signal. For example, in Figure 5.7, there are more than one peak the peak detector algorithm starts with comparing elements such as $s_2 > s_1$ if it is true then it compares $s_3 > s_2$ continues till it reaches $s_5 > s_4$ which is false. In this step a straight horizontal line from the left and right of the point s_4 will create as shown the dashed lines in Figure 5.8 dashed lines will create. The intersection between the horizontal line and the signal indicates to another highest peak in the signal. Next, the comparing steps apply again to find the new peak and a new horizontal line crated on the top of the new peak as shown in Figure 5.8. However, the horizontal line on the new peak not intersecting with the rest of the signal furthermore it reaches the end of the signal from the left and right meaning it is the maximum point on this signal.

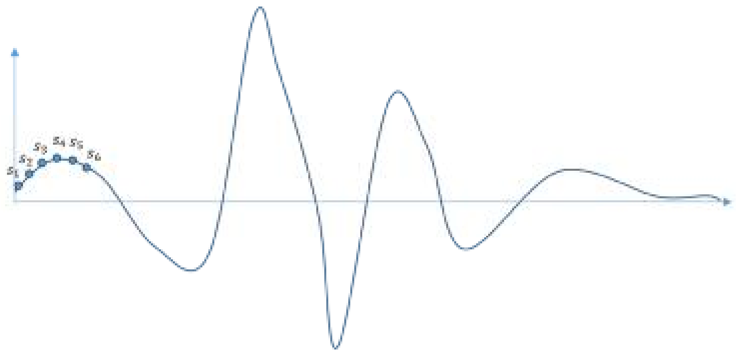

Figure 5.7. Points In the signal.

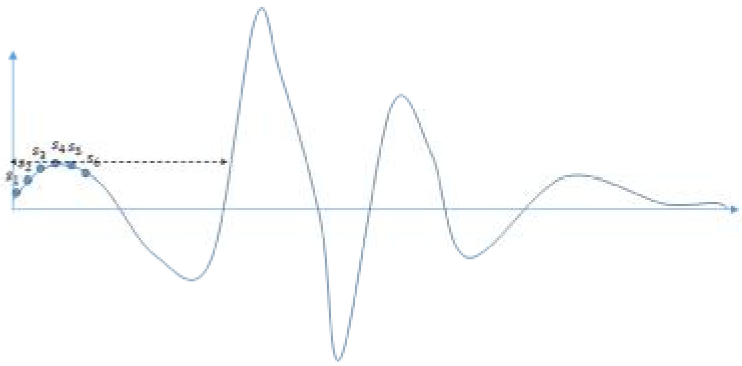

Figure 5.8. Dashed lines will create.

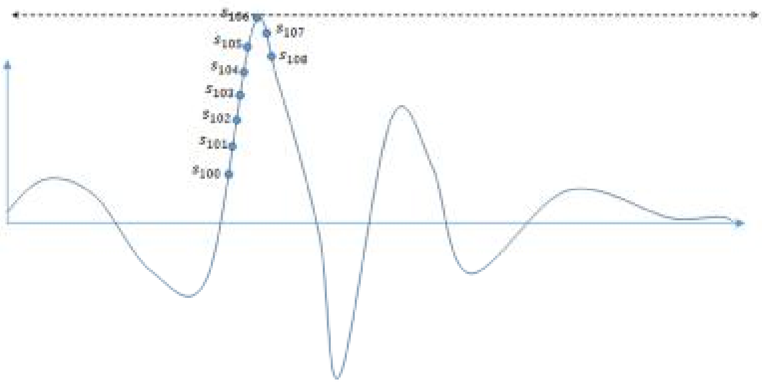

Figure 5.9. maximum new peak.

5.2.1.2. Finding the optimum scale for continuous wavelet transform.

The continuous wavelet method depends on the two main parameters named wave function and wave scale. Numerous studies extract the R-peaks from the ECG signal using Daubechies 3 wavelet function (Gordan and Reiz, 2005) due to the similarity in the shape of the signal with the heat beat signal as illustrated in the Figure 5.10. However, regarding the wave scale studies proposed different methods (Aqil et al., 2016) to detect the beat size of the wave function. The importance of the scaling is due to the variation in the heart beat rate.

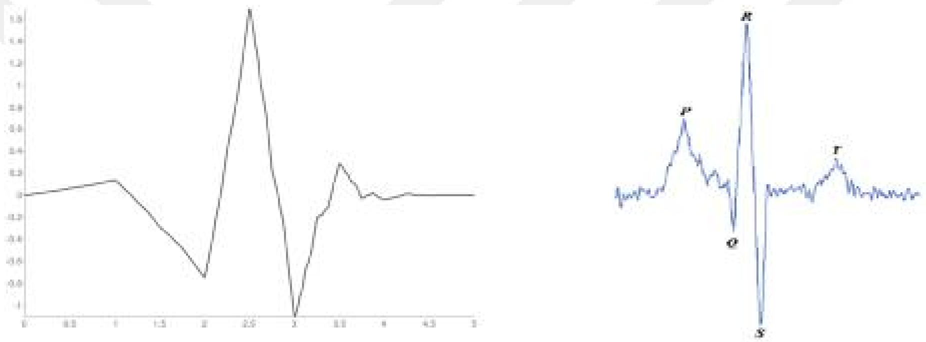

Figure 5.10. db3 and heart beat wave shape.

In this section, the scaling optimization algorithm will present as shown in block diagram in Figure 5.11. The first step starts with importing and reading the measured signal. Herein, the measured data of single hand of the person No.1, 2, 3 and 4 will import as shown in Figures 5.12 a, 5.13 a, 5.14 a, 5.15 a. Next, the wavelet method will apply to the signal with Different scale factor (in this study the selected scales between 1 and 60) and the coefficients for each scale will store in a matrix. The row and column of this matrix represent the coefficient for each scale and sample respectively. Then, the index and value of the maximum coefficient for each column will store in separate vectors. After that, the vector of the maximum coefficient values will plot and shown in Figures 5.12 b, 5.13 b, 5.14 b and 5.15 b and the peaks of the plot will obtain as shown in Figures 5.12 c, 5.13 c, 5.14 c, and

5.15 c. Later, from the index of the obtained peaks will evaluate. The index refers to the scales which show maximum separation between the R-peaks and the rest of data. Table 5.2 shows all the result obtained for signals.

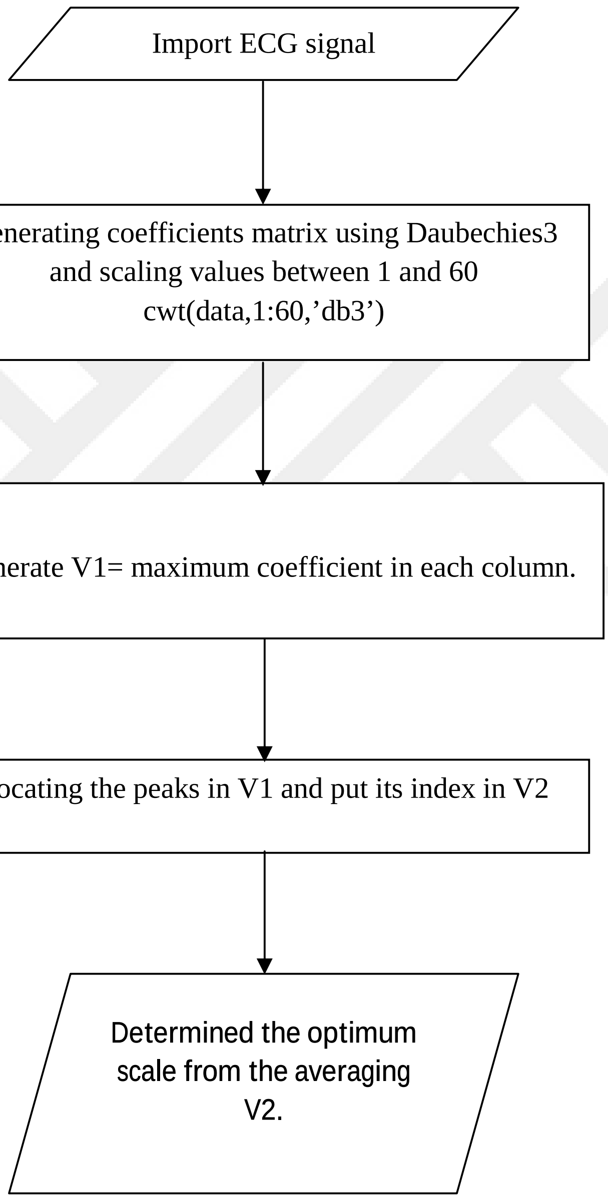

Figure 5.11. Block diagram of scaling optimization algorithm

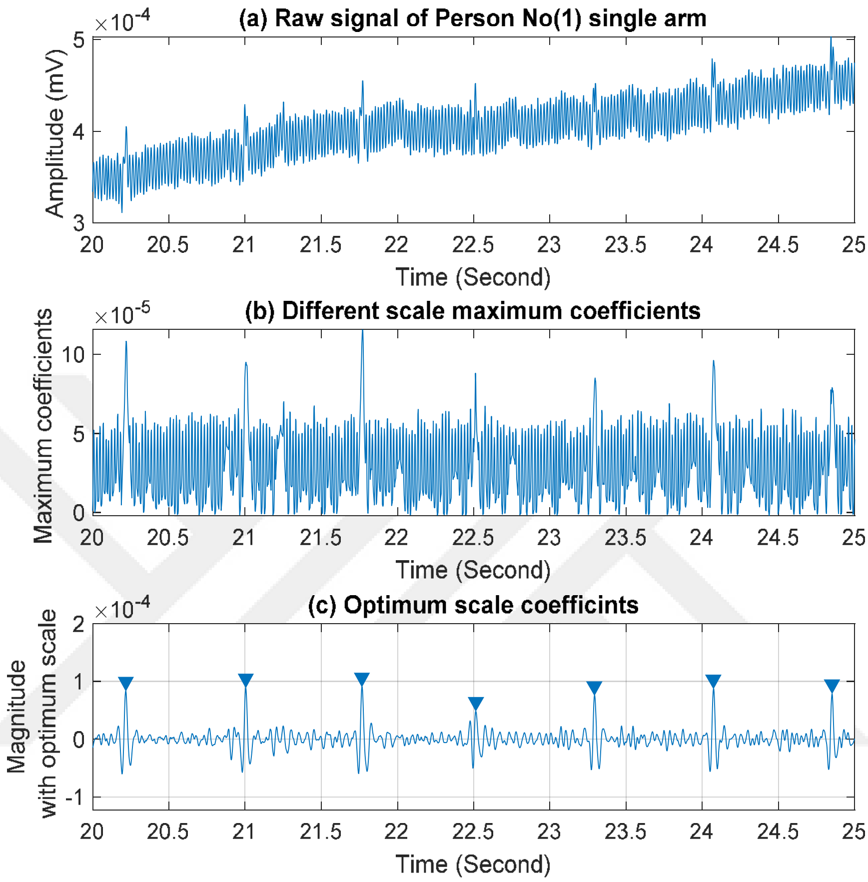

Figure 5.12.. Optimum scale for continuous wavelet transforms for person no 1.

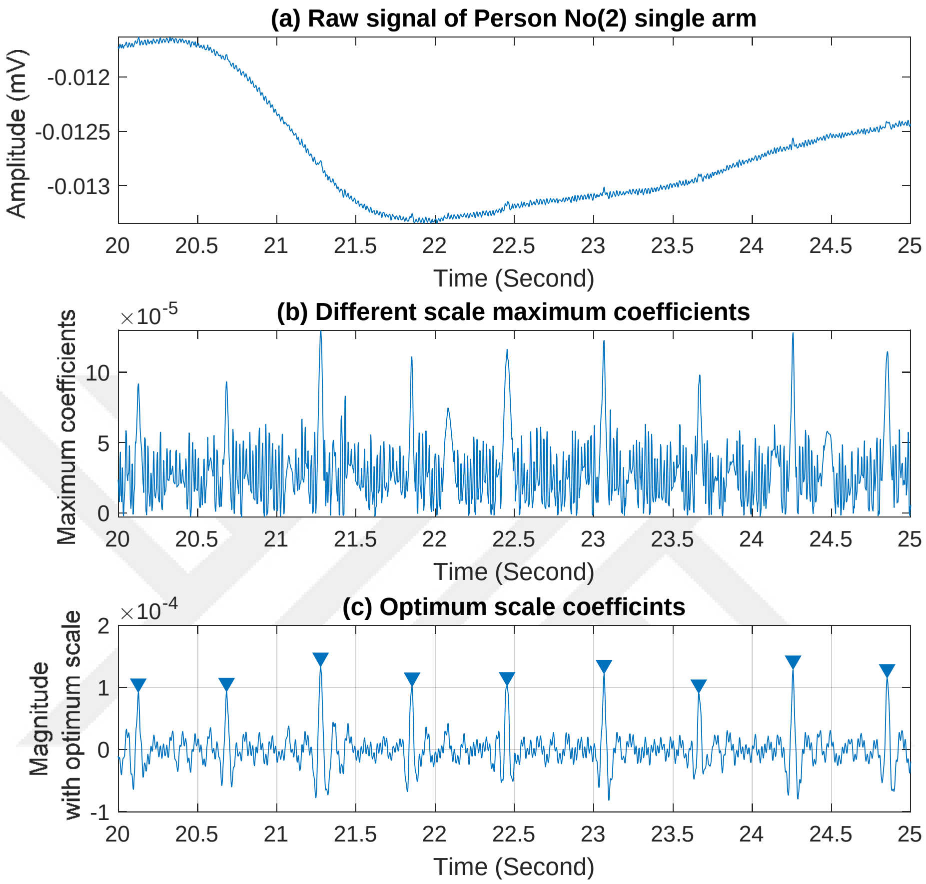

Figure 5.13. Optimum scale for continuous wavelet transforms for person no 2.

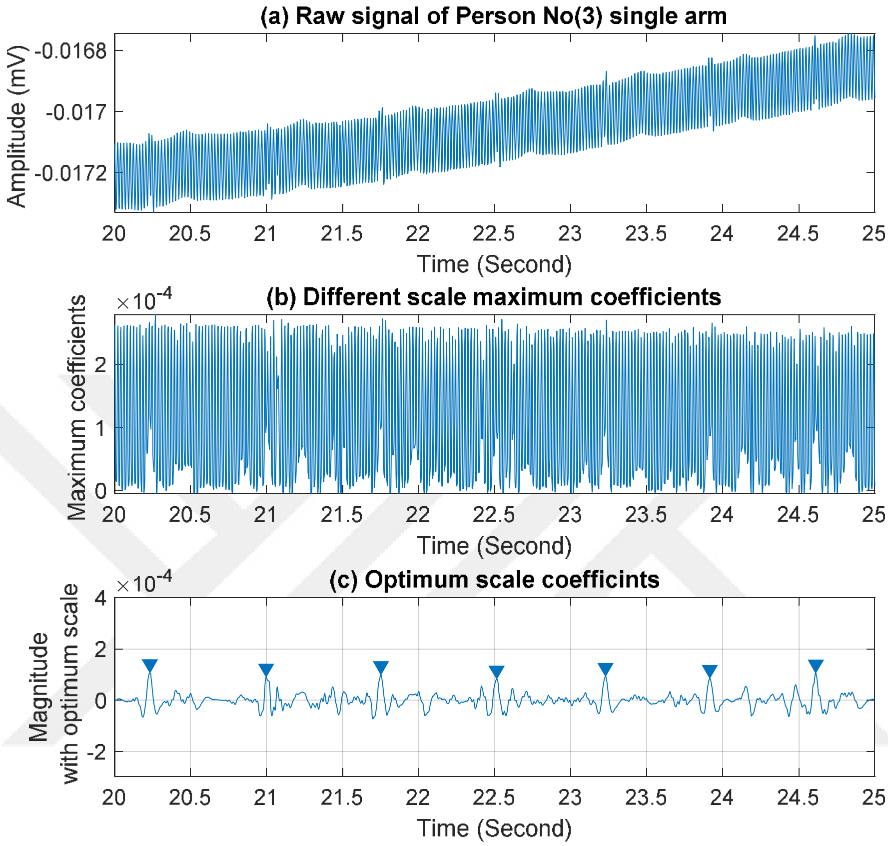

Figure 5.14. Optimum scale for continuous wavelet transforms for person no 3.

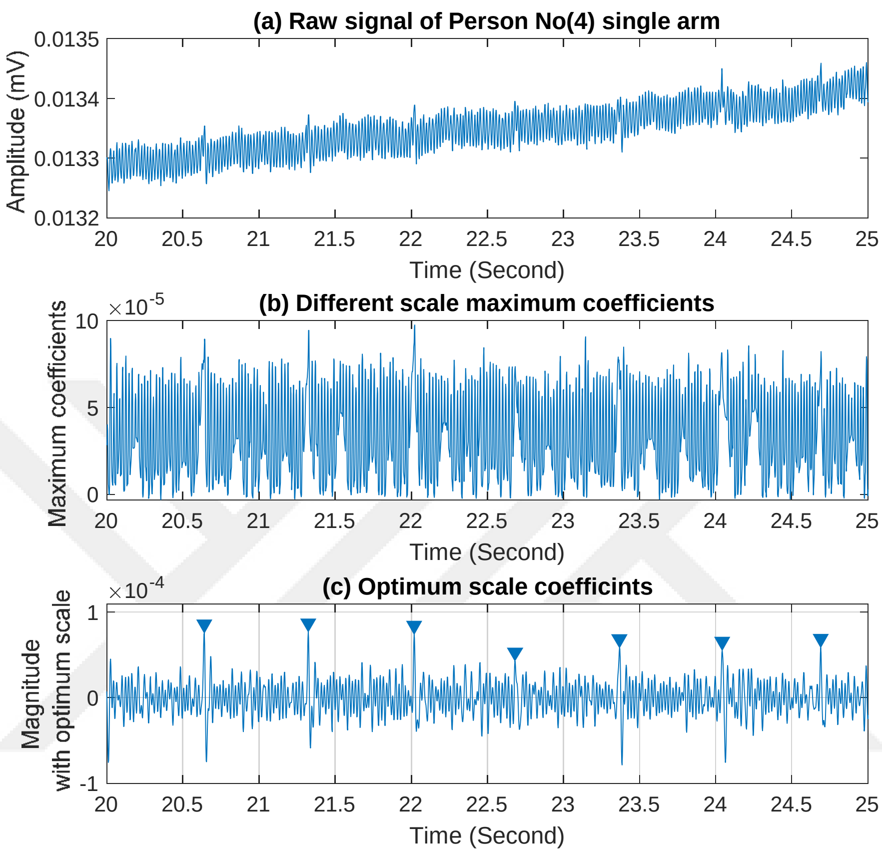

Figure 5.15. Optimum scale for continuous wavelet transforms for person no 4.

Table 5.2. Result of (CWT) With Scaling Algorithm.

	Data No.	Scaling Continuous Wavelet transform	Optimum Scale
Person 1	D1	78	16.9512
	D2	78	26.4805
Person 2	D3	105	26.9167
	D4	105	22.3786
Person 3	D5	83	37.7143
	D6	83	32.6098
Person 4	D7	93	13.8221
	D8	93	35.0879

5.2.2. Correlation Coefficient

A correlation coefficient measures the strength and direction of a linear association between two variable data. It ranges from -1 (perfect negative correlation) through 0 (no correlation) to +1(perfect positive correlation).

If the two variable data have a strong positive linear correlation, close to +1 this indicates a perfect positive fit. Positive value also indicates a relationship between two random variables, such as if one of the two the values increases, the other one will also increase. In the other hand if the two values have a negative linear correlation close to -1, which indicates a perfect negative fit. Negative values also indicate a relationship between two values such as if one of the values increase, the other value will decrease. Lastly, if there is no linear correlation or weak linear correlation, the value is near to the zero which means that there is a nonlinear relationship between the two variables. The correlation coefficient can be expressed as in (Gerstman, 2003) (Hall, 2015).

$$\textbf{Correlation Coefficient} = \frac{\sum(\mathbf{X}-\mathbf{X'})(\mathbf{Y}-\mathbf{Y'})}{\sqrt{\sum(\mathbf{X}-\mathbf{X'})^2(\mathbf{Y}-\mathbf{Y'})^2}}$$

Where:

X': mean value of X.

Y': mean value of Y.

The correlation in this study used as in the continuous wavelet method. A model of single ECG heartbeat selected as a reference data; see Figure 5.16, to compare it with the similar data size (window size) along of the raw signal. Then, the window shifts in time to scan the entire signal and generate a correlation coefficient related with each window as shown in Figure 5.17, where the Figures 5.18 a, 5.18 a, 5.18 a , and 5.18a. Shows the raw input single hand measurements for the person no1, 2, 3, and 4 respectively, Table 5.3 shows all correlation coefficient result. The correlation coefficients plot Figures 5.18 b, 5.18 b, 5.18 b, 5.18 b, show a good separation between the R-Peaks and the rest of the signal, which significantly helps in detect the beat rate. This method essentially shows how the continuous wavelet methods work. However, the compared wave shapes in the wavelet method is limited to specific shapes according to the tool package but herein the wave customize according to the requirement.

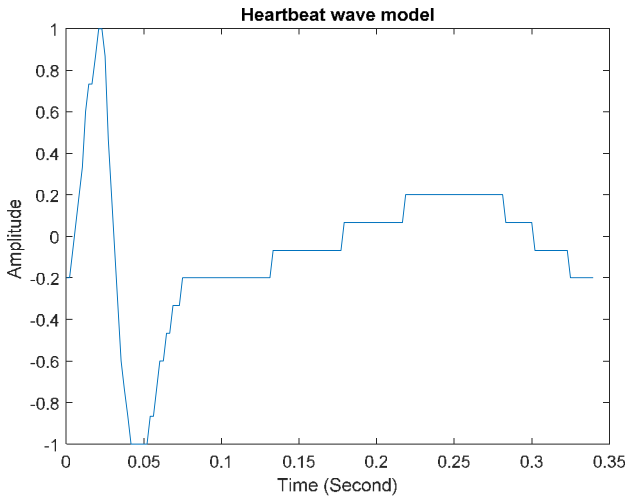

Figure 5.16 heartbeat wave models.

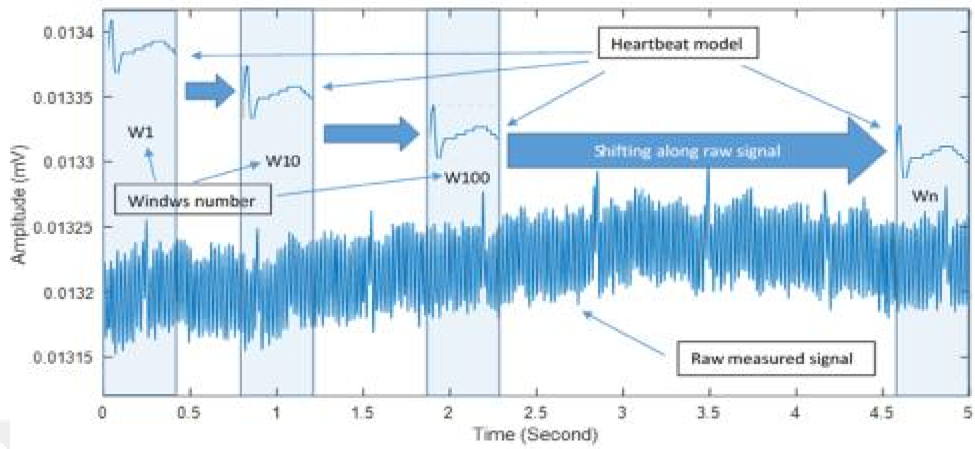

Figure 5.17 window shifts in time to scan the entire signal.

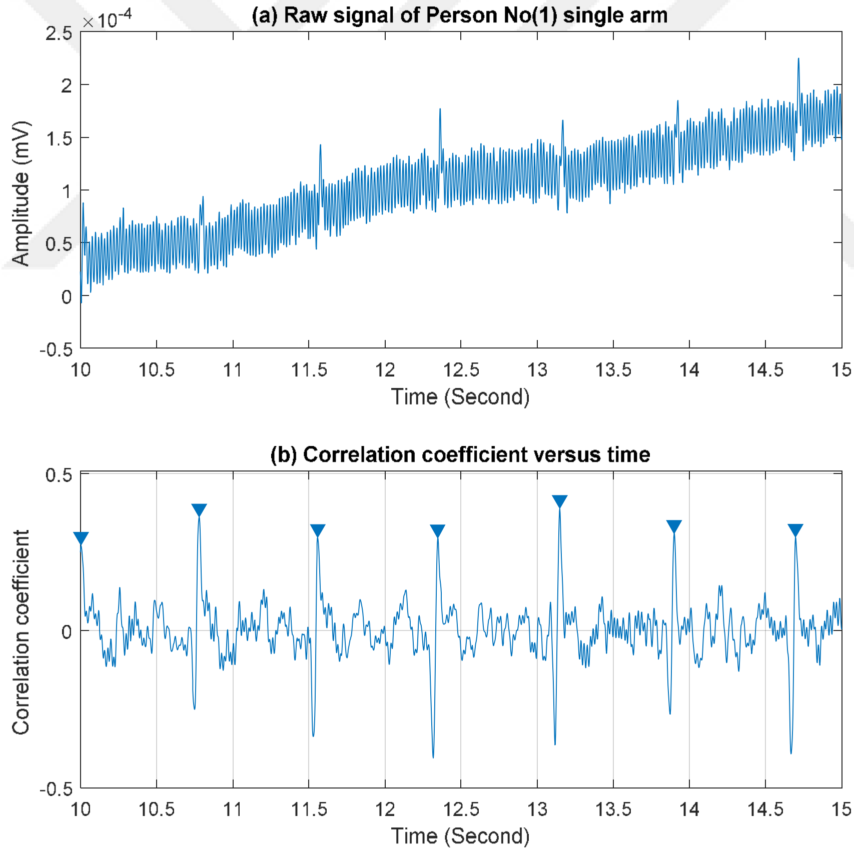

Figure 5.18 Raw inputs single and the correlation coefficient for single arm Person No.1.

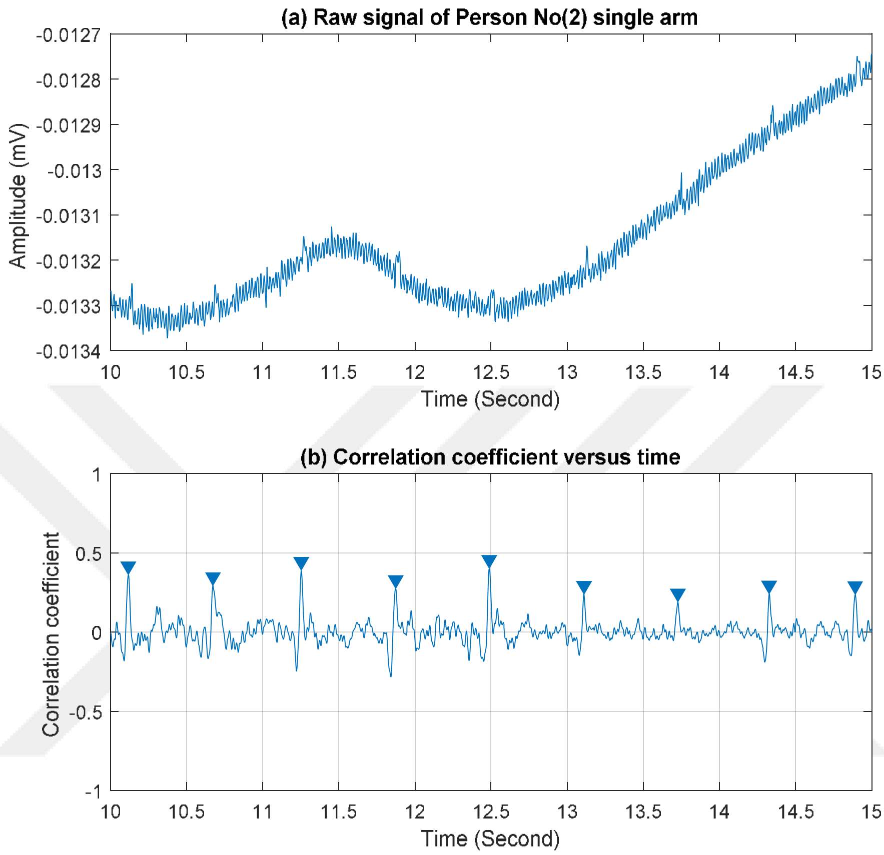

Figure 5.18 Raw inputs single and the correlation coefficient for single arm Person No.2.

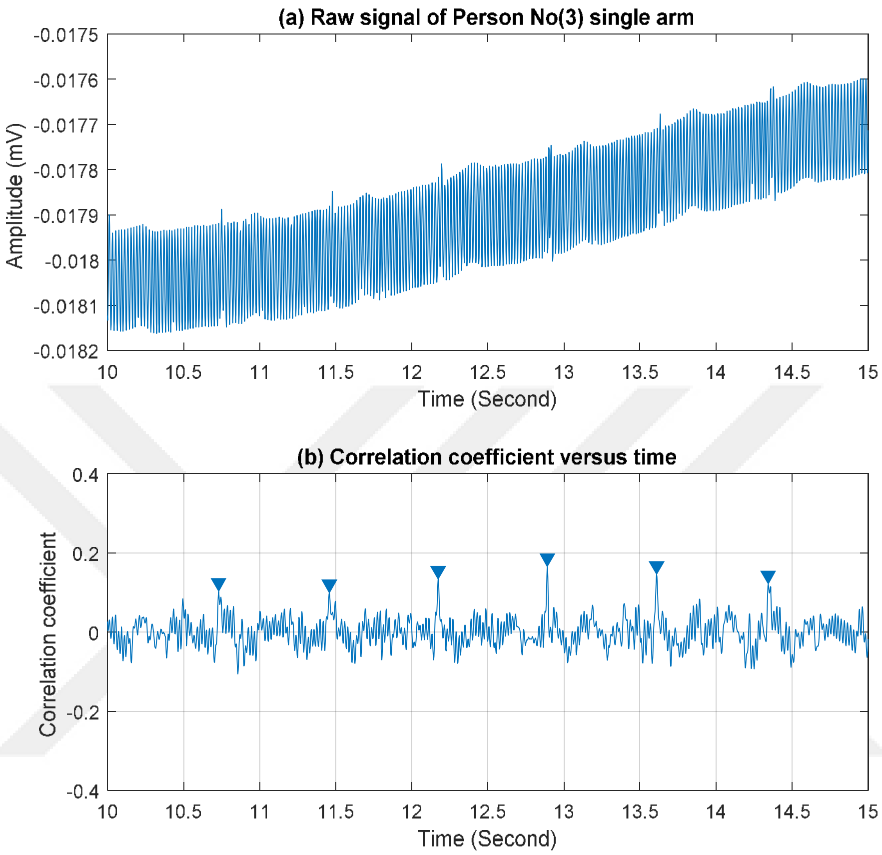

Figure 5.18 Raw inputs single and the correlation coefficient for single arm Person No.3.

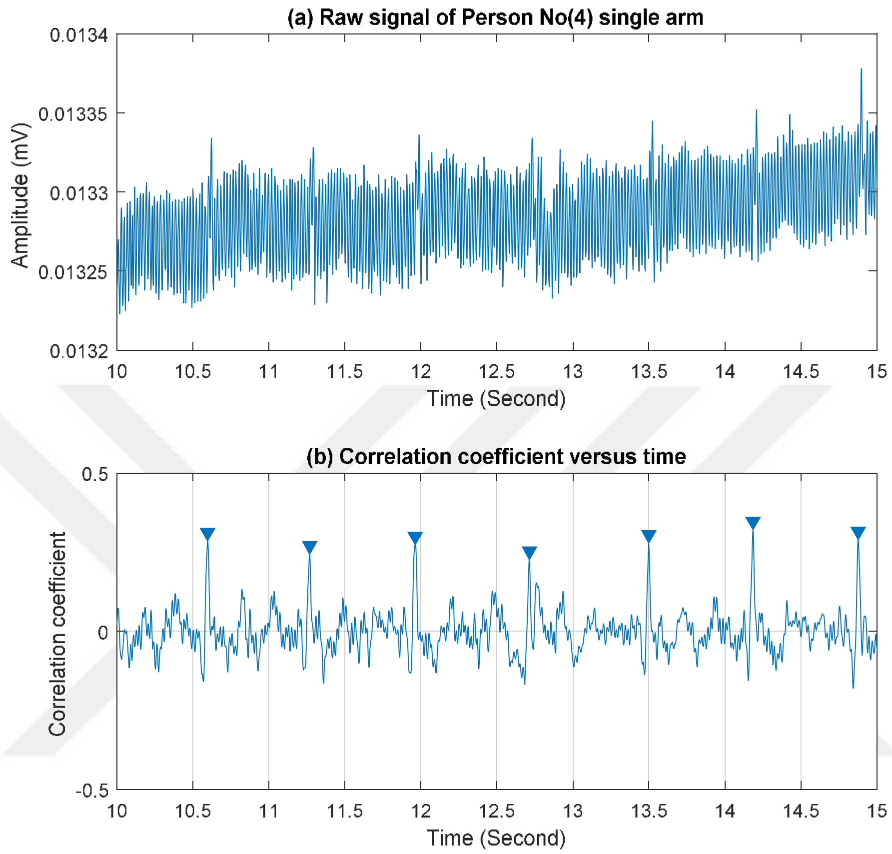

Figure 5.18 Raw inputs single and the correlation coefficient for single arm Person No.4.

Table 5.3. Correlation Coefficient Result.

	Data No	Correlation Coefficient
Person 1	D1	78
	D2	78
Person 2	D3	105
	D4	105
Person 3	D5	83
	D6	83
Person 4	D7	93
	D8	93

5.2.3. Modal Assurance Criterion

One of the most common methods for the quantitative comparison of modal vectors is the Modal Assurance Criterion (MAC). The MAC originally used in vibration analysis to add confidence for the results that obtained from two different methods or between the simulation and the experimental measurements. Basically, this tool generates a coefficients related to the similarity between to shape vectors. However, the coefficients in MAC are between 0 and 1 according to the similarity is the shapes. Where 1 indicates to the perfect matches between two vectors and value near 0 refers to not consistent between vectors. The MAC coefficient is a statistical indicator which is most sensitive to large differences and relatively insensitive to small differences in the mode shapes. This indicator is used in this instead of the continuous wavelet or correlation formulation. Nevertheless, the procedure of the algorithm similar to the previously used method in correlation. A single heartbeat signal figure 5.19 is used as a model to compare with the ECG measured signal.

According to (Pastor et al., 2012) the MAC can be expressed as:

$$\mathbf{MAC}\,(\boldsymbol{\varphi}_{\mathbf{A}}, \boldsymbol{\varphi}_{\mathbf{X}}) = \frac{\left|\{\boldsymbol{\varphi}_{\mathbf{A}}\}^{T}\ \{\boldsymbol{\varphi}_{\mathbf{X}}\}\ \right|^{2}}{\left(\{\boldsymbol{\varphi}_{\mathbf{A}}\}^{T}\{\boldsymbol{\varphi}_{\mathbf{A}}\}\ \right)\left(\{\boldsymbol{\varphi}_{\mathbf{X}}\}^{T}\{\boldsymbol{\varphi}_{\mathbf{X}}\}\ \right)}$$

Where:

φ_A: single heart beat model

φ_X: Raw measured signal

^{T}: Refers to matrix transpose

Figures 5.20 forward is the result of the heartbeat that obtained from single arm measurement using the Modal Assurance Criterion (MAC) method, where figures 5.20 a , 5.21 a, 5.22 a, 5.23 a, the raw measured signals from single arm of person No. 1,2,3 and 4, respectively. The MAC coefficients plots for the person No. 1, 2, 3 and 4 are shown in figures 5.20b, 5.21b, 5,22b, 5.23b. Also Table 5.4 shows the total result of the MAC method.

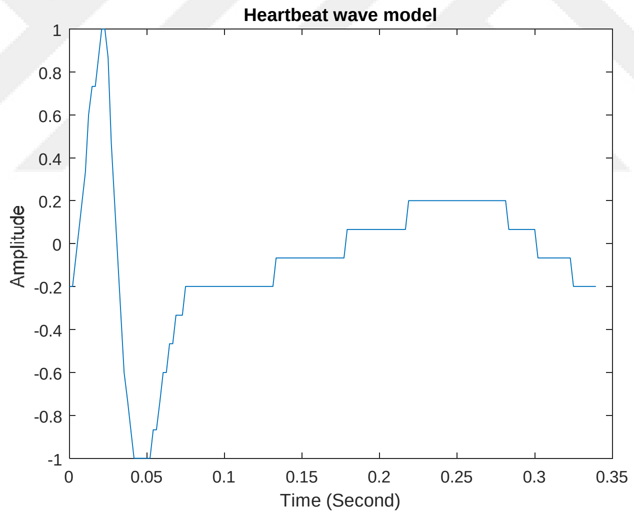

Figure 5.19. heartbeat wave model.

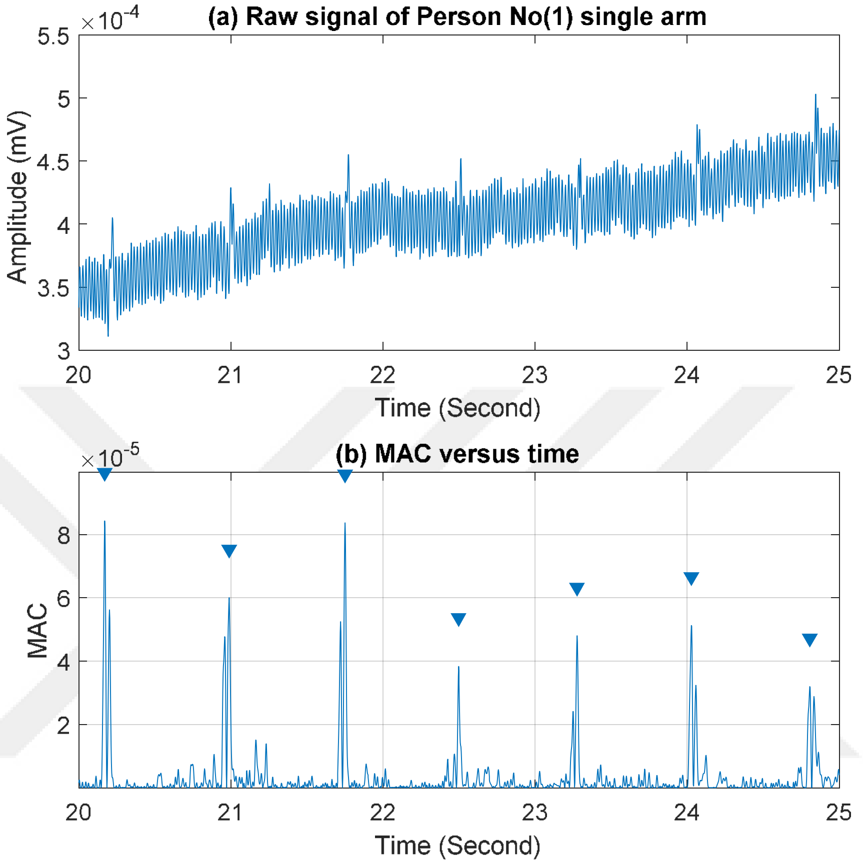

Figure 5.20. Raw inputs single and MAC result for single arm of Person No.1.

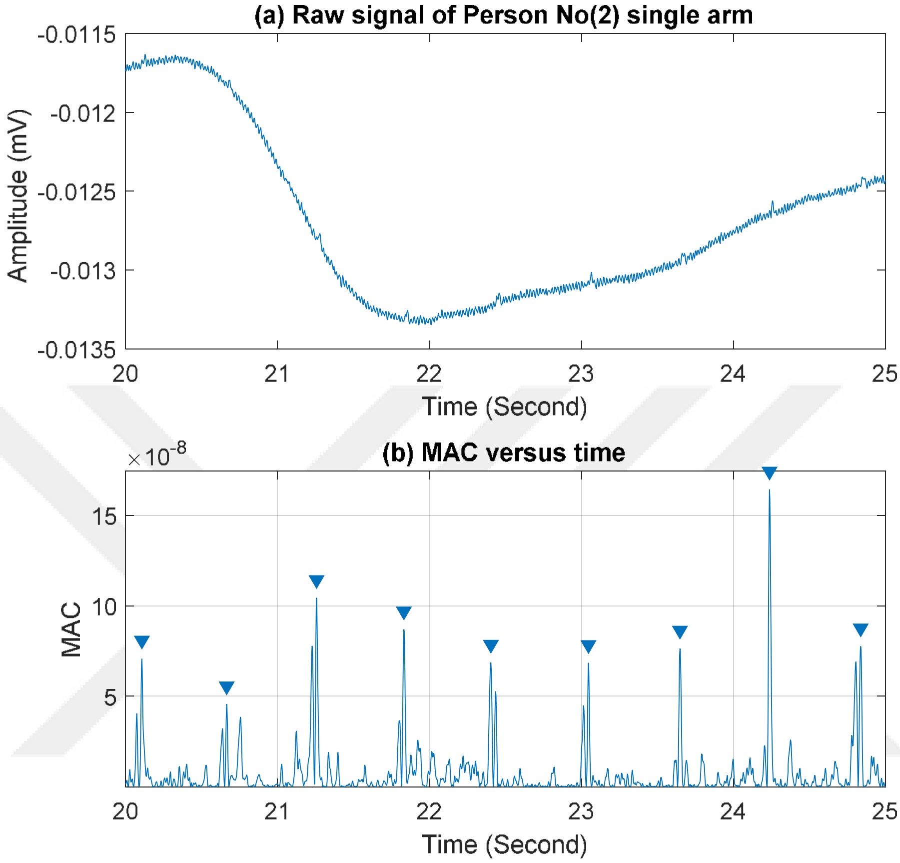

Figure 5.21. Raw inputs single and MAC result for single arm of Person No.2.

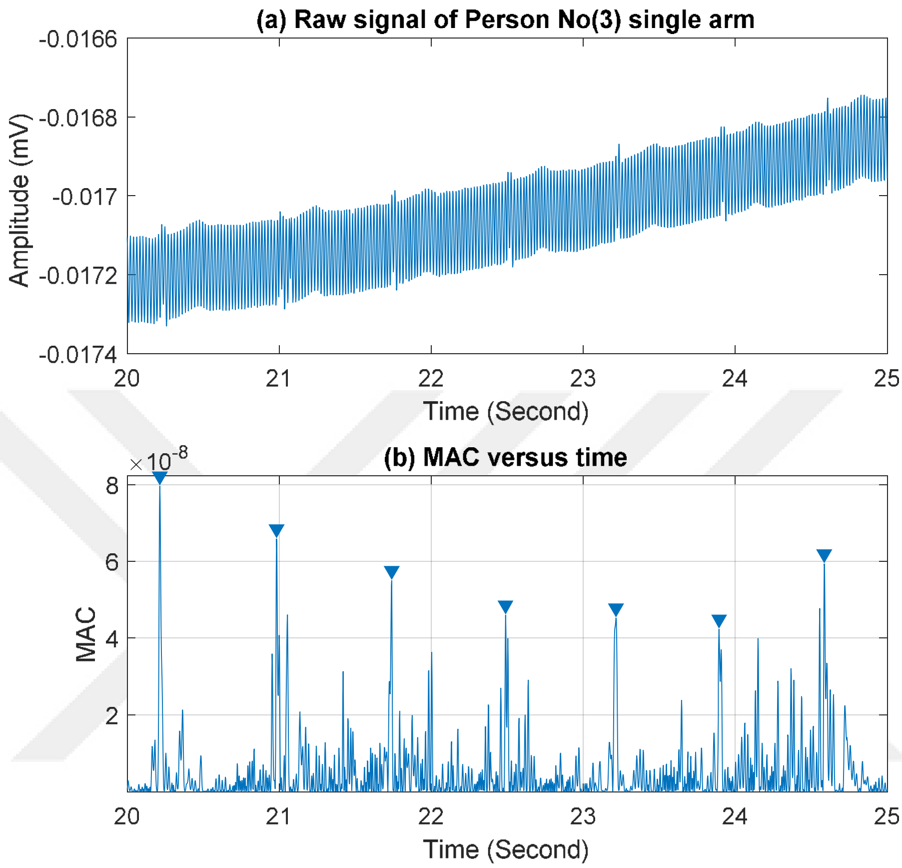

Figure 5.22. Raw input single and MAC result for single arm of Person No.3.

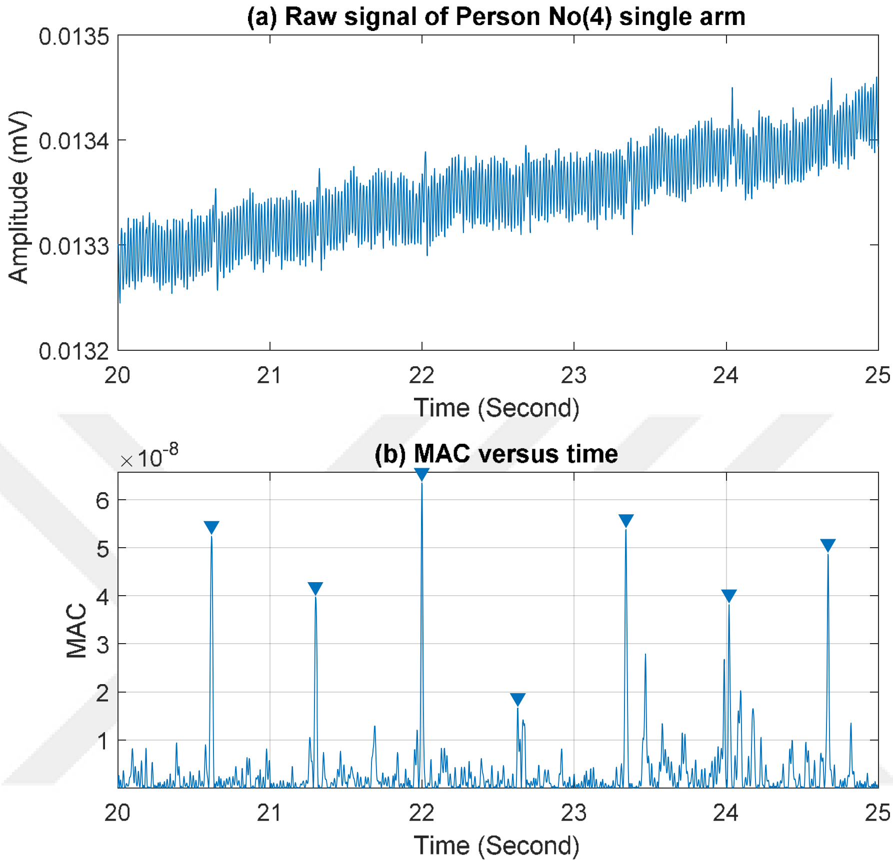

Figure 5.23.Raw Inputs single and MAC result for single arm of Person No.4.

Table 5.4. Modal Assurance Criterion Result.

	Data No	Modal Assurance Criterion
Person 1	D1	78
	D2	78
Person 2	D3	104
	D4	105
Person 3	D5	83
	D6	83
Person 4	D7	91
	D8	93

6. RESULT AND DISCUSSION

The measured signals from single arm are heavily contaminated with noise comparing with the signals measured from the double arm as shown in Figure 5.24. The source of noise as presented early in this thesis is mainly the power line interference (PLI), contact point resistor changes and signals from the other muscles. However, the classical signal processing methods such as using high or low pass filters are less efficient in cleaning the signal due to losing information from the raw signal.

In this thesis, the continuous wavelets transform (CWT) method (Aqil et al., 2016) considered as a reference method in post processing the measured signals due to the detecting small changes in the signal regarding to the time and frequency. All the three different methods are compared with the mentioned (CWT). However, the CWT method with fixed scale showed a difference about one beat in counting the heart rate between single and double arm for the person No.1, 3 and 4 as shown in Table 5.1. The numbers between the single and double arm should be produce the same beat rate due to they are measured simultaneously.

The (CWT) method is improved in the second step by adding scaling algorithm. This algorithm used to auto select the scaling for each measured signal as described in the scaling algorithm section .The separation between the R-peaks and the rest of the signal become more distinguished, which allow to the peak finder to detect the peaks more accurate. The results for the CWT method with the scaling algorithm showed a matching results between the single and double arm. Table 5.2, present the CWT results with auto scale. The scale is selected by the algorithm for each measured signal to detect the heartbeats accurately as listed in the same table.

Regarding correlation coefficient method, the results in good matching with the previously mentioned methods (CWT and CWT with scaling). Similar to CWT with scaling algorithm the correlation coefficient method shows a perfect matching between the single and double arm results. The results of correlation coefficient is listed in Table 5.3 and it gives the same number of heartbeats as in improved CWT method.

The modal assurance criterion method also predicts similar results to the mentioned three methods. Nonetheless, the results which obtained from the measured signal of the person No.2 and 4 showed difference in the result between single and double arm result. The result of single arm for person No.2 is 104 beats per minutes while the double arm is 105 beats per minutes. For person No.4 the obtained heartbeats for single arm is 91 beats per minutes and 93 beats per minutes for the double arm. The MAC method showed maximum error about 2 beats as listed in Table 5.4.

Overall, the measured signal from the person No.4 especially the single arm signal shows a difference in the results between two methods named CWT and MAC coefficient. The proposed new method (MAC coefficient method) showed similar results to the popular methods in this field, i.e. in ECG heartbeat counting, such as CWT. Furthermore, the MAC method can be optimized by utilizing the scaling algorithm to predict an accurate result. The results of the all methods are listed in the Table 5.5.

Table 5.5. The results of the all methods.

	Data No.	CWT	Scaling	Correlation Coefficient	MAC
Person 1	S1	77	78	78	78
	D2	78	78	78	78
Person 2	S3	105	105	105	104
	D4	105	105	105	105
Person 3	S5	82	83	83	83
	D6	83	83	83	83
Person 4	S7	94	93	93	91
	D8	93	93	93	93

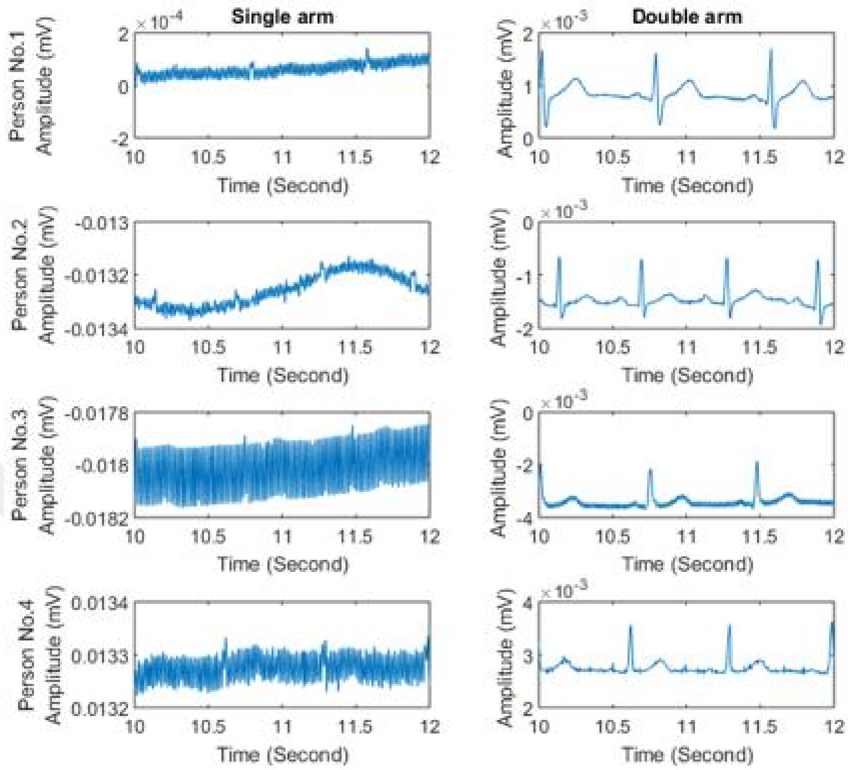

Figure 5.24 the comparison between single and double arm noise level.

7. CONCLUSION AND FUTURE WORK

In this study, the heartbeat signal is measured using single and double arm simultaneously. Using ADS1298ECG-FE. The single arm measured signals was heavily contaminated with noise. The signals post processed using four different signal processing methods named continuous wavelets transform (CWT), CWT with scaling algorithm, correlation coefficients and modal assurance criterion (MAC) coefficients. The MAC coefficient is used in this study, which is originally developed for the mechanical vibration analysis, and the result showed high potential to establish a new reliable method. The results compared with previous work. The results from different methods showed a good matching with maximum error of two beat at the MAC method while the other methods less than one beat per minutes. The results of CWT with scaling algorithm and Correlation methods show reliable outputs and equal results between single and double arm. The devise with combination of the presented methods promise a potential to develop a wearable devise in the near future.

The scaling algorithm and correlation coefficient method on the other hand shows perfect majority result in the heart beat which make it the best reliable output in this thesis.

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