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Detection of Cardiac Arrhythmia Abnormalities Using NN based ECG analysis system

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ABSTRACT: - *In this paper presents a method to analyze ECG signal and detection of Cardiac Arrhythmia in an ECG. A one complete cycle in an ECG signal design of the P-QRS-T waves. The ECG (electrocardiogram), which records heart's electrical activity, is able to provide with useful information about the type of Cardiac disorders suffered by the patient depending upon the deviations from normal ECG signal pattern. Cardiac Arrhythmias shows a condition of abnormal electrical activity in the heart which is a threat to humans. These abnormalities of heart may cause sudden cardiac arrest or cause damage of heart. The early detection of arrhythmia is very important for the cardiac patients. Cardiac Arrhythmia is the most common cause of death. Cardiac arrhythmias which are found are Tachycardia, Bradycardia, Supraventricular Tachycardia, Incomplete Bundle Branch Block,Ventricular Tachycardia.*

Keywords – Electrocardiogram (ECG), Cardiac Arrhythmias, P-QRS-T Segment, Electrical Cardioversion

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I. INTRODUCTION

The ECG device detects and amplifies the tiny electrical changes on the skin that are caused when the heart muscle depolarizes during each heartbeat. At rest, each heart muscle cell has a negative charge, called the membrane potential, across its cell membrane. Decreasing this negative charge toward zero, via the influx of the positive cations, Na^+ and Ca^{++}, is called depolarization, which activates the mechanisms in the cell that cause it to contract. During each heartbeat, a healthy heart will have an orderly progression of a wave of depolarization that is triggered by the cells in the sinoatrial node, spreads out through the atrium, passes through the atrioventricular node and then spreads all over the ventricles. This is detected as tiny rises and falls in the voltage between two electrodes placed either side of the heart, which is displayed as a wavy line either on a screen or on paper. This display indicates the overall rhythm of the heart and weaknesses in different parts of the heart muscle. The ECG consists of several electrodes which are attached to the body of the patient and are connected by wires to the device. The device itself consists of a graphing device (originally paper, although electronic recorders are becoming more common). Each one of the sensors can detect a change in electrical charge in the skin that can only be the result of the impulses that are travelling through the heart and on to the rest of the body. It is measured in several directions simultaneously, and by interpreting the electrical currents of the heart throughout a series of heartbeats, from several angles. A piece of graph paper is dragged past a marker hooked to the measurement device of the electrical current at a fixed rate, and this leaves a graph of the net electrical current between two electrodes [1].

An ECG also can show:-

(a) Arrhythmia Abnormalities: - A heartbeat that's too fast, too slow, or irregular
(b) Heart failure:-A heart that doesn't pump forcefully enough
(c) Cardiomyopathy: - Heart muscle that's too thick or parts of the heart that is too big cardiomyopathy
(d)Congenital heart defects Birth in the heart
(e) Heart valve disease Problems with the heart valves
(f) Pericarditis Inflammation of such that the surrounds the heart [2] [3].

II. WAVES AND INTERVALS OF ECG

The ECG produces a distinctive waveform in response to the electrical changes taking place within the heart. The ECG signal is characterized by five peaks and valleys labeled by the letters P, Q, R, S, T. In some cases we also use another peak called U. The first part of the wave, called the P wave, is a small increase in voltage of about 0.1 mV that corresponds to the depolarization of the atria during atrial systole. The next part of the ECG wave is the QRS complex which features a small drop in voltage (Q) a large voltage peak (R) and another small drop in voltage (S). The QRS complex corresponds to the depolarization of the ventricles during ventricular systole. The atria also repolarize during the QRS complex, but have almost no effect on the ECG

because they are so much smaller than the ventricles. The final part of the ECG wave is the T wave, a small peak that follows the QRS complex. The T wave represents the ventricular repolarization during the relaxation phase of the cardiac cycle [4].

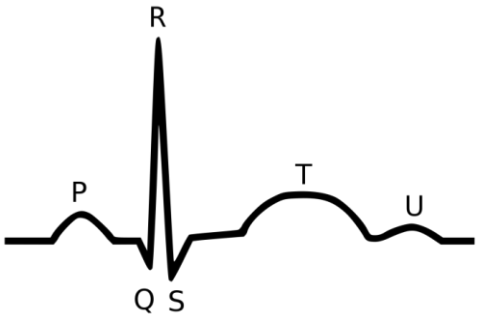

Figure1: ECG waveforms

P wave: - P wave represents atrial depolarization.
Q wave:-The Q wave represents the normal left-to-right depolarization of the interventricular septum.
QRS complex: - Represents ventricular activation or depolarization.
J point:-The J point is the junction between the termination of the QRS complex and the beginning of the ST segment.
T wave:-The T wave is the positive deflection after each QRS complex. It represents ventricular depolarization.
U Wave:-The U wave is a small (0.5 mm) deflection immediately following the T wave, usually in the same direction as the T wave [5] [6].
Clinical important Parameters
PR-Interval: - The PR interval reflects the time the electrical impulse takes to travel from the sinus node through the AV node and entering the ventricles. The PR interval is, therefore, a good estimate of AV node function. Duration of PR-Interval is 120 to 200ms.
PR-Segment: - The PR segment connects the P wave and the QRS complex. This electrical activity does not produce a contraction directly and is merely traveling down towards the ventricles, and this shows up flat on the ECG. The PR interval is more clinically relevant. Duration of PR-Segment is 50to120ms.
QRS-Complex: - The QRS complex reflects the rapid depolarization of the right and left ventricles. Duration of QRS-Complex is 80 to 120ms.
ST- Segment: - The ST segment connects the QRS complex and the T wave. The ST segment represents the period when the ventricles are depolarized. It is isoelectric. Duration of ST-Segment is 80to120ms.
ST- Interval: - The ST interval is measured from the J point to the end of the T wave. Duration of ST-Interval is 320ms.
QT-Interval: - The QT interval is measured from the beginning of the QRS complex to the end of the T wave. Duration of QT-Interval is up to 420 ms in heart rate of 60 bpm.
RR-Interval: - The interval between an R wave and the next R wave; normal resting heart rate is between 60 and 100 Bpm Duration of RR-Interval 0.6 to 1.2s [7].

III. CARDIAC ARRHYTHMIA ABNORMALITIES

The term "arrhythmia" refers to any change from the normal sequence of electrical impulses. The electrical impulses may happen too fast, too slowly, or erratically – causing the heart to beat too fast, too slowly, or erratically. When the heart doesn't pump blood effectively, the lungs, brain and all other organs can't work properly and may shut down or be damaged [8].

Cardiac arrhythmias are disturbances in the normal rhythm of the heartbeat. An occasional palpitation or fluttering is usually not serious, but a persistent arrhythmia may be life threatening. There are many different types of cardiac arrhythmias. The heart may beat too rapidly, known as atrial tachycardia, or too slowly, known as bradycardia, or it may beat irregularly. Atrial fibrillation and atrial flutter are common cardiac arrhythmias, which lead to an irregular and sometimes rapid heart rate [9].

Causes
There are many causes for arrhythmias, however a fast or slow heart rate does not always mean your heart rhythm is abnormal [10].
Arrhythmias may be caused by many different factors, including:
- Coronary artery disease.
- Electrolyte imbalances in your blood (such as sodium or potassium).

- Changes in your heart muscle.
- Injury from a heart attack.
- Healing process after heart surgery.
- Irregular heart rhythms can also occur in "normal, healthy" hearts.

Symptoms of cardiac arrhythmia

● Palpitations or irregular-feeling heartbeats.
● Shortness of breath.
● Chest pain (discomfort)
● Dizziness, lightheadedness, and fainting spell.
● Mental confusion.
● Loss of consciousness
● Weakness or fatigue

There are many types of Arrhythmias diseases

• Atrial Fibrillation = upper heart chambers contract irregularly
• Bradycardia = slow heart rate
• Conduction Disorders = heart does not beat normally
• Premature contraction = early heart beat
• Tachycardia = very fast heart rate
• Ventricular Fibrillation = disorganized contraction of the lower chambers of the heart [11].

Cardiovascular diseases are one of the most frequent and dangerous problems in modern society nowadays. Therefore, it is very difficult to take immediate measures without real time electrocardiogram (ECG) information [12].

IV. STRUCTURE OF THE HEART

The heart contains 4 chambers: the right atrium, left atrium, right ventricle, and left ventricle. The heart has four chambers, two on the right and two on the left:

●Two upper chambers are called atria (one is an atrium).
●Two lower chambers are called ventricles.

The heart also has four valves that open and close to let blood flow in only one direction when the heart contracts (beats). The four heart valves are:

● Tricuspid valve, located between the right atrium and right ventricle
●Pulmonary or pulmonic valve, between the right ventricle and the pulmonary artery
● Mitral valve, between the left atrium and left ventricle
● Aortic valve, between the left ventricle and the aorta [13].

The heart circulates blood through two pathways: the pulmonary circuit and the systemic circuit. In the pulmonary circuit, deoxygenated blood leaves the right ventricle of the heart via the pulmonary artery and travels to the lungs, then returns as oxygenated blood to the left atrium of the heart via the pulmonary vein. In the systemic circuit, oxygenated blood leaves the body via the left ventricle to the aorta, and from there enters the arteries and capillaries where it supplies the body's tissues with oxygen. Deoxygenated blood returns via veins to the venae cavae, re-entering the heart's right atrium [14].

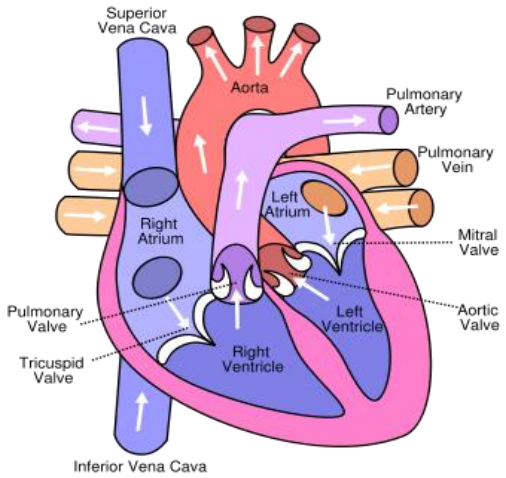

Figure 2:- Structure of Human Heart

The atria are smaller than the ventricles and have thinner, less muscular walls than the ventricles. The atria act as receiving chambers for blood, so they are connected to the veins that carry blood to the heart. The ventricles are the larger, stronger pumping chambers that send blood out of the heart. The ventricles are connected to the arteries that carry blood away from the heart. The chambers on the right side of the heart are smaller and have less myocardium in their heart wall when compared to the left side of the heart. This difference in size between the sides of the heart is related to their functions and the size of the 2 circulatory loops [15].

V. METHODOLOGY & FEATURE EXTRACTION OF ECG

It is one of the key tests performed when a heart attack is suspected; the ECG can identify whether the heart muscle has been damaged in specific areas, though not all areas of the heart are covered. The ECG cannot reliably measure the pumping ability of the heart, for which ultrasound-based (echocardiography) or nuclear medicine tests are used. Initially ECG Signals are preprocessed for removal of power line noise and high frequency interference. Then deflections in the ECG Signal Q, R, and S are identified and through these deflections QRS complex is identified which is a very important feature in identifying arrhythmias. A neural network is trained with 20 dataset containing features of QRS complex which are maximum QRS width, minimum QRS complex width, Average QRS width and the Heart Rate. Once trained, the network is tested on 20 more datasets which have gone through the same procedure as by training dataset [16].

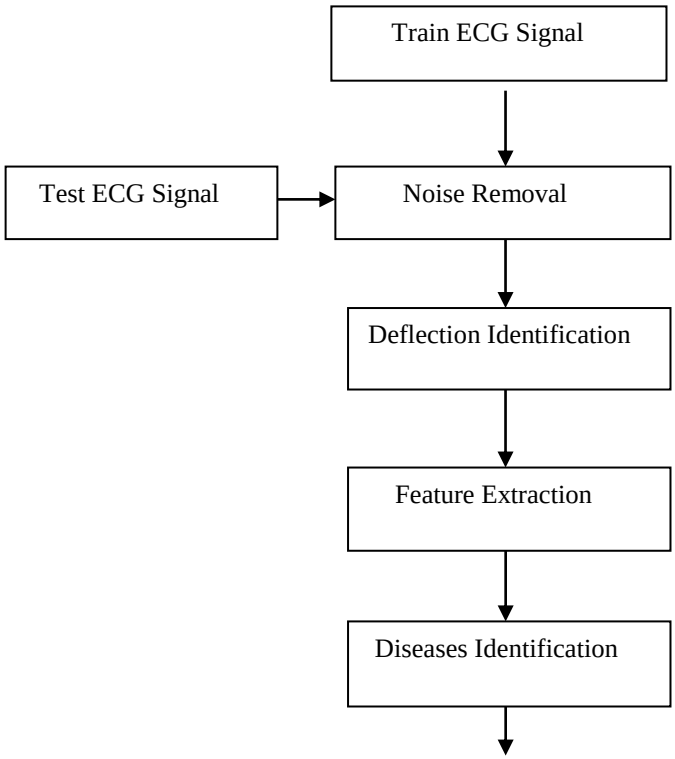

Figure 3: - Methodology Diagram of ECG

Feature extraction for the worst case ECG signal which involves lots of noise with it and high variations is taken to prove the efficiency of the system. With these features various Cardiovascular Arrhythmias are detected as Right bundle branch block. Right bundle branch block is a delay or block of conduction within the right bundle branch. A delay of conduction manifests as incomplete right bundle branch block. A QRS duration greater than 0.14 sec results in right bundle branch block. Bradycardia occurs on resting heart rate of under 60 beats per minute, though it is seldom symptomatic until the rate drops below 50 beat/min. Tachycardia refers to rapid beating of the heart as a heart rate greater than 100 beats per minute in adult. Diseases were predicted from these features derived as according to medical science for Tachycardia heart rate > 100 bpm (beats per minute) [19]. Normal Sinus Rhythm is 60 to 100 bpm. Ventricular tachycardia for heart rate is from 101 to 250 bpm and QRS width > 0.12 sec. Normal QRS width is 0.04 - 0.10 sec. Incomplete Bundle Branch Block for QRS width between 0.10 sec and 0.12 sec and Bundle Branch Block for QRS width > 0.12 sec.

VI. CONCLUSION

This research aims to design an ECG analysis system that will measure the rate and regularity of heartbeats. This system need a good quality and accurate of analysis output to make sure the result of the heart problem are correct. Basically the goals of this research as follows. An electrocardiogram (EKG) can help detect these heart problems.

An electrocardiogram does the following:

(a) Determines the rate and regularity of heartbeats

(b) Measures the size and positioning of the chambers

(c) Evaluates damaged and diseased tissue or other physical irregularities

(d) Monitors any surgical repairs, pacemakers, or effects of drugs used to treat existing heart conditions

(e) An EKG does not measure the heart's ability to pump blood.

An EKG is not usually performed as a preventative measure, and it is only utilized to diagnose or rule out the presence of diseases, disorders, and other irregularities.

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