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INTENSIVE HEALTH MONITORING UNIT USING FPGA

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Abstract: Cardiac arrest is a sudden, abrupt stopping where the heart malfunctions and causes breathlessness, unconsciousness and often leads to a person's death. Today, 85% of the cardiac arrests happen outside the hospitals and it accounts for the 24.8% (2010) of the total deaths in India. Rural areas compared to urban areas are affected more due to the lack of proper hospitalization facilities and awareness of Cardiac Vascular Diseases (CVD). The causes of CVD maybe arrhythmia, cardiomyopathy, valvular heart diseases, sudden heart attacks or electrical malfunctions in the heart. It is said that resurrection by CPR or electric shock in a timely manner can save many lives. Here we propose to design a system to overcome this problem by integrating a pulse oxi-meter in a smart watch to a mobile application and a portable ECG system. The pulse-oximeter records our pulse variations and when the change in variations goes below the threshold value, a beep is sounded from the watch and alert is sent from the mobile application to registered emergency contacts. The user is asked to use the portable ECG and immediate report is sent to user application. If the report appears erratic or has a cause for concern, an alert for ambulance is sent if the patient is at home, or when outside they are urged to go to the hospital. This way, we can give timely intervention to prevent death.

Keywords – *CVD, Sudden Heart Attacks, Pulse-oximeter, Wireless Portable ECG, Smart Watch, User Application.*

I. INTRODUCTION

Cardiovascular Disease which comprises of cardiac myopathy, cerebrovascular, atrial fibrillation, arrhythmia, sudden heart attacks and congenital heart diseases etc., accounts for 3 million deaths in our country. In 2015, at ages 30-69 years, of 1.3 million cardiovascular deaths, 0.9 million (68.4%) were caused by coronary heart disease and 0.4 million (28.0%) by stroke. Rural areas are more affected because they lack proper and adequate hospitalization facilities and they do not have awareness of heart diseases compared to urban areas and these are the increased reasons for remote heart monitoring sensing. About 14 lakh people are affected in the urban areas and 16 lakhs in the rural areas. The data from National Rural Health Mission shows that nearly 8% of primary health centres in rural India were functioning without a doctor, while 61% of them had just one doctor as of March 2017. Urban areas may face lack of timely attention due to which countless lives are lost. We keep researching new methods to offer timely intervention but there are many instances where lives are lost because the cardiac arrests were not detected on time. Patients who have already undergone heart treatments or having heart problems need constant monitoring and they cannot afford to sit at the hospital all their lives and need to have a correct diagnosis at a given time. It is costly and people need to live their daily lives without constantly fearing about their health. Here we bring about an **Intensive Health Monitoring Unit** that serves as a remedy to constantly monitor our heart rate and if abnormalities are detected, the required steps are taken.

Health Band is a device that can be connected to smartphone to receive calls, emails, notifications from applications. This smart watch is integrated with a pulse oxi-meter. A pulse oxi-meter is a non-invasive device which measures blood oxygen level by sending infrared rays and finds out the blood saturation level known as the SpO_2 level. The reading is typically between 95 and 100. A threshold value is set and if the average variation falls below it, it sounds an alert from the watch. This alert prompts the user to check their ECG.

Electrocardiograph (ECG) is a device used to measure the electrical signals from the heart which is generated by the AV node (atrioventricular) and SA (Sino atrial) node in the heart to check its proper functioning. Electrodes are placed on the chest to record the electrical signals from the heart to check its muscle activity and for abnormalities. We cannot always carry an ECG machine with us, for which a wireless portable ECG is designed and incorporated in a FPGA. The output is sent to the smartphone because the processing capability is higher than that of PCs or PDAs. Remote medical sensing of patients has facilitated doctors and improvements in checking heart rate and abnormalities wirelessly have been monumental in saving countless lives and this also brings about satisfaction and authenticity in diagnosis to the patients.

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II. DESIGN

1. HEALTH BAND

Health Band [5] is a device which is interfaced with our smartphones. It can be used to receive calls, e-mails, notifications from applications, etc., It is a combination of physical buttons and touch mechanism. Today, smart watches are used as a fitness device and used mainly to track our health and sometimes calorie count, pulse.

In this project, a health band is interfaced with a smartphone and consists of:

1.1 Pulse oximeter:

Pulse is the rhythmic beating of the heart and in a typical human body the heart beats are between 60-100 per minute. If the pulse rate falls below 60, then it is Bradycardia and if it increases more than 100, it is Tachycardia. We ensure that the heart rate stays at the correct level and if the rate falls below or above, it indicates the malfunctioning of the heart. We use a pulse oxi-meter to monitor the pulse and blood oxygen level. It is a non-invasive device, where two infrared rays are sent, with variations in absorption at each wavelength, by this we can determine the ratio of oxygenated hemoglobin to deoxygenated hemoglobin which is represented by red light and infrared light respectively. The value of the pulse oximeter is typically between 95 and 100 and if this average variated value of the blood oxygen reduces drastically, an alarm is sounded from the watch to alert the user to the decreasing oxygen levels in the body. A report is sent to the user indicating the variations.

1.2 Temperature sensor:

It is an electronic device which is used to measure the changes in temperature of the environment in which it is set in. It generates voltage or resistance when there is a change in temperature. The analog input data is converted to electronic data to monitor, record the changes. Non-contact temperature sensors use IR (infra-red) to sense the IR energy emitted from the object and the temperature is calibrated through this. Accuracy and responsiveness of temperature and temperature control is vital for the ensuring an accurate result. We detect human body temperature and it should maintain at 37° Celsius and not fall below 34° Celsius. If the temperature falls below 34°, it is hypothermia and it can lead to a person's death and above 37°, it is a cause for concern and the person may have to be hospitalized.

All these sensors are integrated in the smart watch to give an accurate reading to determine the health of the patient/wearer.

2. ELECTRODE

An electrode is a conductive device which is used to record the electrical activity of the heart by attaching it to the patient's body at the specified spots. Here, the electrode has two different configurations: three and six leads. The Ag/AgCl [1] electrodes that are commonly used are disposable after one use. It consists of foam base lining material, conductive material and electrode buckle.

3. ECG DEVICE

The ECG signals from the electrodes are sent to the FPGA module through an analog circuit. The FPGA being used is a SPARTAN 3E. It has a pre-amplifier control module for the amplification of the input ECG signal, an ADC module for the conversion of the analog signal to digital signal, a Low Pass FIR filter is used for removing the noise from the signal and a DAC module to convert the noise free digital signal to analog signal. The FPGA module also has a clock generating module and a SPI clock interface for SPI communication.[6] This is then sent to a RF transmitter [3] for transmission of these signals to our mobile application in form of UDP packets. [4].

4. MOBILE APPLICATION

Patient data: [2] This module provides the personal and real-time medical report of the patient. This data was recorded by the sensors present in our smart watch.

Alert message: When there is a variation from the average threshold value that is set, an alert message is sent to the patient's guardian(s). This message comprises of the last recorded variation, the current location of the patient and a prompt to connect the ECG device.

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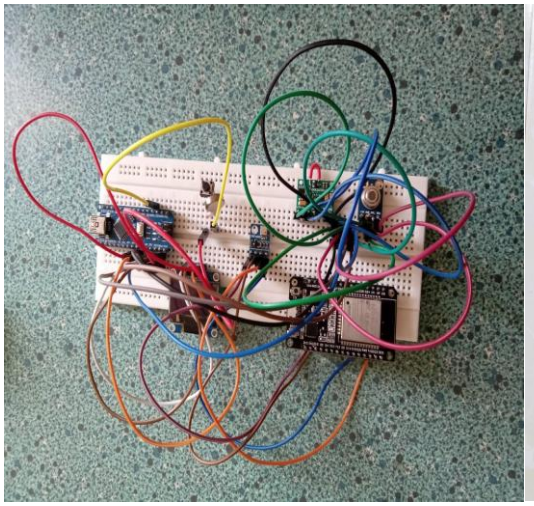
ECG Device: This module helps the user to select the mode of configuration – three/six lead. A lead connection check is done. A complete report of the patient comprising the ECG report, pulse variation, BP, temperature is generated and sent to the registered doctor for further medication. Multiple doctors and nurses can be engaged for diagnosing patients.

Location: This module gives the current location of the patient for the guardian to provide medication and for the doctor to send ambulance.

III. PROPOSED SYSTEM

The principal objective of the proposed system is to provide services for diagnosing cardiac arrest or any other rhythm abnormality. This can markedly decrease the response time of a medical professional to a cardiac arrest. The proposed system incorporates a health band and an ECG device. The health band is made of wearable sensors namely, a MAX 30100 pulse oximeter sensor for the measurement of the oxygen saturation level in blood, an MLX 90614 infrared temperature sensor for the measurement of body temperature, a BMP 180 pressure sensor for notifying when a drastic change in the altitude is noted. Here the Arduino NANO microcontroller is the master of the network and is communicated serially with NodeMCU ESP32 which is the slave of the network. The MAX 30100 pulse oximeter is interfaced with the Arduino NANO, while MLX 90614 infrared temperature sensor and the BMP 180 pressure sensor is interfaced with the NodeMCU. In addition to these sensors, we have an OLED 0.96 inches display for displaying the sensor readings. A vibration motor is interfaced with the Arduino NANO which vibrates when a drastic variation in any sensor is noted. We also provide an emergency switch for the patient to notify the guardian for immediate attention. The sensor data is monitored by the guardian using IOT which uploads it to the cloud. When a drastic variation is sensed by the wearable sensors in the health band, an alert message is sent to the patient's guardian. After being notified the guardian rush for the connection of the ECG device and an immediate first aid is given in case of cardiac arrest. With the ECG graph the patient can be diagnosed. For the ECG device, we have an Ag/AgCl electrode which is connected to the patient's Right Arm, Left Arm and Right Leg. The weak electrical signal observed is amplified using ECG IC which then sends it to an Arduino UNO microcontroller board. Using SPI protocol, the Arduino UNO board which is the master is interfaced with the slave such as Xilinx XL9600 FPGA board. The code is written is VHDL and fed on the FPGA board.

IV. RESULT



HEALTH BAND

ECG DEVICE

V. EASE OF USE

This project aims to ease the health issues faced by heart patients. Using this device reduces the amount of time spent in hospitals and instead get on with their daily lives. This project also aims to track our health and maintain it. It also gives a complete report to the guardian(s), for them to provide timely medication.

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