Design of Remote Health Monitoring System

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***Abstract*— The way of life has been altered by the Internet of Things and its developing multidisciplinary applications. Smart Healthcare being one such IoT application connects smart devices, machinery, patients, doctors, sensors to the internet. When it comes to health bills, resource requirements and availability, and personal care, healthcare has become a major socio-economic concern, particularly in rural areas and for the elderly. This new healthcare trend has enabled doctors to do remote monitoring, chronic illness management, and senior care of remote patients, as well as caring after institutionalized patients, in an effective and intelligent manner. The project aims to develop a remote health monitoring platform using IoT to help in proper remote diagnosis of patients by doctors by using a wholly indigenous developed easy-to-use device that can be operated by oneself or under supervision as deemed fit.**

***Index Terms*— Smart Healthcare, IoT, Telemedicine, microcontroller, NodeMCU, Arduino, Android App**

I. INTRODUCTION

Every time the human race advances in terms of technology, health is always a huge worry. The recent Corona virus onslaught, due to which millions of people lost their lives, economies of various countries suffered, is an illustration of how health care has grown increasingly important. It is always a better option to monitor these individuals utilizing remote health monitoring technologies in places where the virus has spread. As a result, the current solution is an Internet of Things (IoT)-based health monitoring system. Remote Patient Monitoring allows for patient observation outside of traditional clinical settings (e.g., at home), which increases access to human services offices while lowering costs. The main goal of this project is to create and construct a smart patient health tracking system that employs sensors to monitor patient health and the internet to notify loved ones if there are any problems. This remote delivery of healthcare services, including exams and consultations, over the telecommunications infrastructure is known as telemedicine.

Telemedicine uses telecommunications technology to provide health care services to patients who are at some distance from the doctor. The idea behind Telemedicine is to act as a bridge between the doctors and patients for those segments of society for which medical facilities are hard to avail. All the residents of that region need to do is connect the machine to the prescribed place, and the vitals of their will be measured and will be sent to a doctor in a faraway place from where they can evaluate and tell the patient the further steps of action.

The project aims to develop **a remote health monitoring platform using IoT** to help in proper remote diagnosis of patients by doctors by using a wholly indigenous developed easy-to-use device that can be operated by oneself or under supervision as deemed fit.

II. MOTIVATION

The goal of building remote health monitoring systems is to lower health-care expenditures by lowering doctor visits, hospitalizations, and diagnostic testing procedures and also looking into the current society, especially in the rural establishments of India, the medical facilities are very poor, and this is due to various reasons; one of the main reasons is that the doctors do not want to go into rural areas. Also, looking upon the geographical region in which the medical services are required in India, it is not an easy task to execute; we need to consider making no. of hospitals, providing quality medical treatment in all of them, professional in fields at every hospital. Sometimes, it is tough to even reach a hospital on time due to a lack of transportation facilities in the region. Due to these difficulties, millions of people have suffered during the current COVID-19 pandemic. The motivation behind this project is to propose a smart healthcare solution for these situations when proper medical facilities are not easily available.

III. METHODOLOGY

The complete plan of the remote health monitoring device is to measure different biomedical parameters using a microcontroller (for computations) , a Wi-Fi module (for data transmission), and various sensors to measure the vitals of the patients. Currently Prof Sudip Kundu is considering **three measurement schemes in his research:**

A. *Electro- Cardiograph (ECG)*

It produces an electrocardiogram using an Electro-Cardiograph setup. **An Electrocardiogram helps in the diagnosis of several common heart problems that include abnormal heart rhythm, blocked or narrow arteries causing chest pain**, history of heart attack, etc.

B. Pulse- Oximeter

It measures the level of oxygen saturation in the blood and the patient's pulse rate by **a non-invasive differential electronic circuit**. It can be really useful in several different cases, such as determining if someone needs help in breathing, evaluating how helpful a ventilator is, assessing someone's ability to tolerate increased physical activity, etc. Further, it can **determine early symptoms of hyperoxemia/hypoxemia.**

C. Blood-Pressure

It measures the blood pressure of a patient under observation. It can help in determining if the blood pressure is in the normal range. **The accurate measurement and control of blood pressure are key elements in the prevention of cardiovascular disease and stroke.**

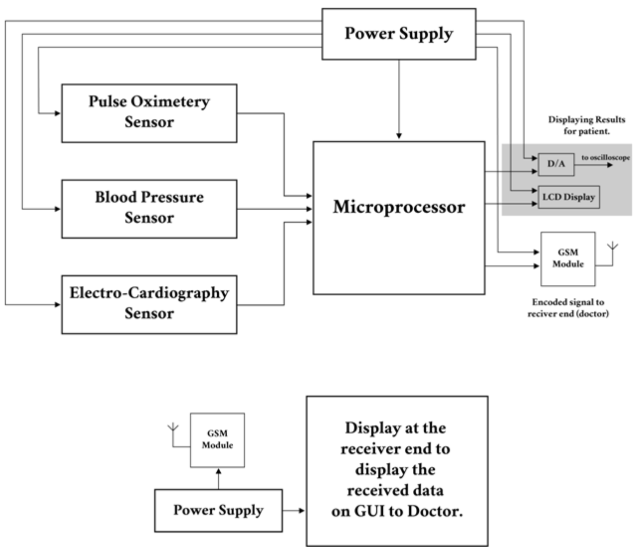


Fig. 1.1 Block diagram of complete Project

I am assigned to complete the Electro-Cardiograph (ECG)
The proposed Instrumentation system for biomedical device mainly consists of three modules:

A. Signal Acquisition

B. Signal Processing

C. Signal Transmission

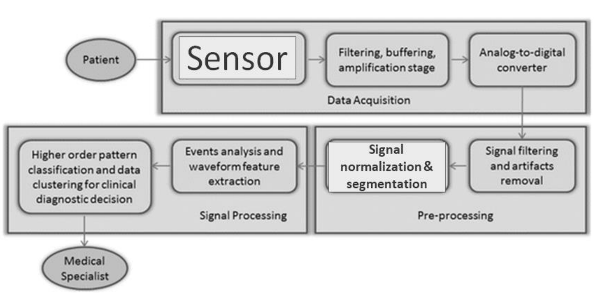


Fig: Block diagram of digital biomedical signal acquisition, processing and analysis

IV. ELECTROCARDIOGRAPHY

An ECG or Electrocardiogram (also known as EKG, which is abbreviated from the German word: Elektro-Kardiographie) refers to the electrical recording of the heart during a cardiac cycle and is used in the investigation of heart disease. It can also reveal irregularities in the heart's rhythm known as 'arrhythmia.' The ECG is a valuable, non–invasive diagnostic tool that was first put to clinical use in 1913. The bandwidth of an ECG signal with a 12 lead historically has been 0.05 - 150 Hz, but with recent standards and the specific patient population being viewed, the values may range. The peak amplitude of the signal ranges from 0.01 mV to 5 mV.

Working Principle:
The Electrocardiogram is a surface measurement of the electrical potential generated by electrical activity in cardiac tissue. Current flow (in the form of ions) indicates the contraction of cardiac muscle fibers leading to the heart's pumping action.

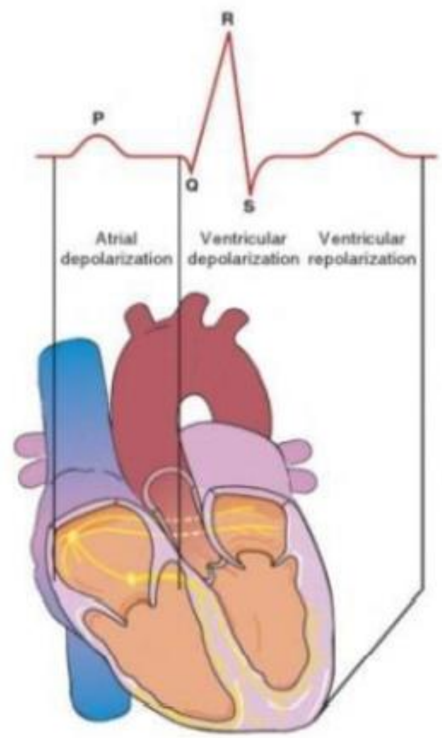


Fig: How a heartbeat is represented as a signal (Jones, 2009)

Placement of electrodes
Einthoven described a system of three bipolar leads located at the right arm, left arm, and left leg to form a triangle. Lead I represent the potential difference between the right and left arm; an electrical impulse moving from right to left generates a positive ECG deflection in this lead.

$$aVR = V_{RA} - 0.5\,(V_{LA} + V_{LL}) \qquad I = V_{LA} - V_{RA}$$

$$aVL = V_{LA} - 0.5\,(V_{RA} + V_{LL}) \qquad II = V_{LL} - V_{RA}$$

$$aVF = V_{LL} - 0.5\,(V_{LA} + V_{RA}) \qquad III = V_{LL} - V_{LA}$$

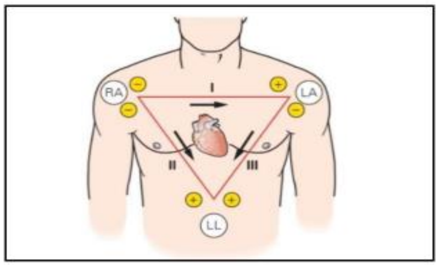


Fig: Einthoven's Triangle of the Bipolar Limb Leads

Electrodes:

Each electrode consists of an electrically conductive electrolyte gel and a silver/silver chloride conductor. The gel typically contains potassium chloride – sometimes silver chloride as well – to permit electron conduction from the skin to the wire and to the electrocardiogram. The electrode gel reduces the electrical impedance at the point of contact with the skin so that this impedance is as small as possible to avoid attenuation of the signal.

Components Required

A. NodeMCU (ESP8266-12E Board)

We choose NodeMCU because it is less expensive as compared to other development board and it have inbuilt Wi-Fi module which is a major advantage over Arduino Uno.

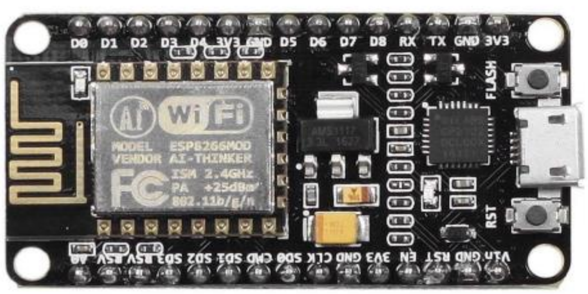


Fig: ESP8266 module (User guide 2017)

B. ECG Sensor (AD8232 ECG Sensor Kit)

For ECG and other biopotential measurement applications, the AD8232 is an integrated signal conditioning block.

It's made to extract, amplify, and filter tiny biopotential signals in noisy environments like those caused by mobility or remote electrode placement.

The AD8232 module exposes nine pins, wires, or other connectors on the IC that can be soldered to.

The pins SDN, LO+, LO-, OUTPUT, 3.3V, and GND are required for use with NodeMCU or other development board.

This board also has RA (Right Arm), LA (Left Arm), and RL (Right Leg) connectors for connecting and using your own custom sensors. There is also an LED indication light that will pulsate in time with a heartbeat.

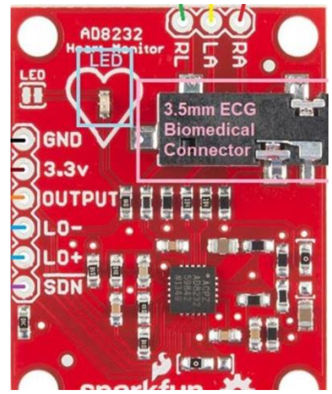


Fig: AD8232 sensor (sparkfun 2016)

C. Data Cables (5V micro USB)

For receiving the sensor data and sending it to a cloud server, NodeMCU development board has to be programmed first and for connecting NodeMCU to computer we need a micro usb cable.

D. Breadboard and Jumper wires

For making connections breadboard and jumper wires were used.

Software Used

A. Arduino IDE
B. Thingspeak Cloud Server by MATHWORKS
C. Android Studio

Circuit Diagram

Interfacing of AD8232 ECG Sensor was done with NodeMCU. Output of AD8232 was connected to Analog pin A0 of NodeMCU, L0+ and L0- to D5 and D6 of NodeMCU respectively. VCC of AD8232 was connected to 3.3V and GND to GND. Now the electrodes of the AD8232 ECG sensors are attached near the right arm, left arm, and left leg to form a triangle (Einthoven's Triangle).

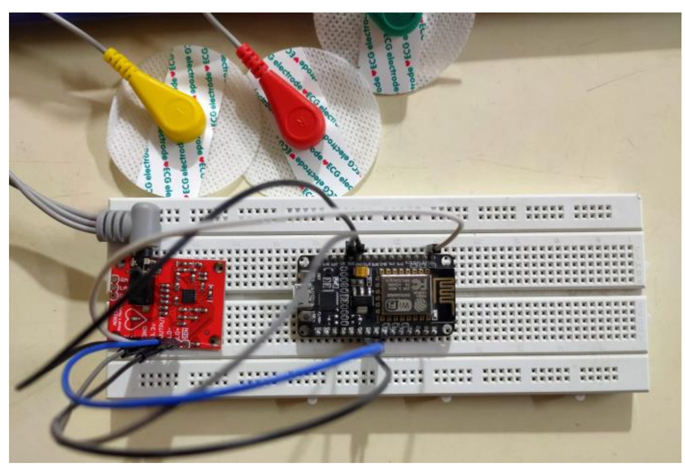


Fig: circuit connections

V. Signal Transmission and Data Presentation

To visualize the ECG waveform remotely, we have to use a cloud server to store the data and build an application for the user interface. In this project, we have used a popular cloud server mainly for IoT applications -"thingspeak" (by MATHWORKS) as a cloud server because it is free of cost up to some limit, provides real-time data visualization, and we can use Matlab language to generate various plots on the data stream.

Due to unavailability of the ECG sensor, I have used a dataset available on the internet, and used those data values as a input array to the NodeMCU, and transmitted the data serially to cloud server using protocols like I2C and MQTT.

Link to the dataset: here
Link to my Arduino code: here

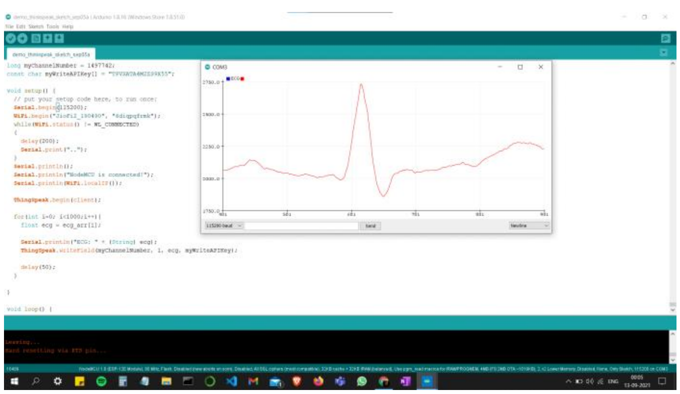
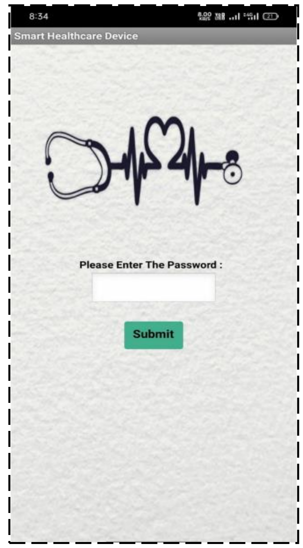
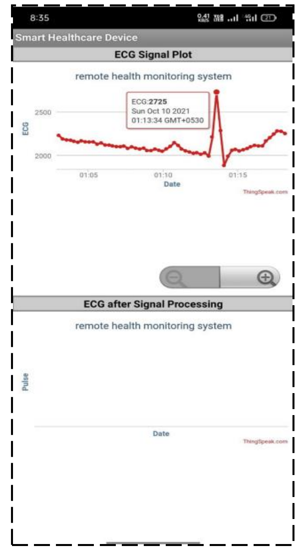


Fig: sending the real-time data to a cloud server using MQTT protocol

Android Application – link to download





VI. Conclusion and Future Plans

By applying IoT in the healthcare sector, we are building a preventative and proactive healthcare system instead of just offering reactive treatment when illnesses are diagnosed. The entire health system is focusing on prevention so that individuals do not have to suffer the harsh consequences of diseases.

Smart monitoring systems help in detecting symptoms quickly and treating them on time. This is great for both physicians and patients as the stress is reduced immensely. Moreover, patients can receive personalized treatments with the help of IoT-enabled devices as doctors can get a clear picture of their lifestyle and case history.

Future plan includes:

- Analyzing the sensor output ECG waveform using instruments like cathode-ray oscilloscope (CRO) at NIT Labs.
- Generate more accurate results by better placement of electrodes and using some better electrolyte gel and a silver/silver chloride conductor.
- Real time transmission of the generated ECG signal to the developed android application.
- Detecting R-peaks and measuring a person's heart rate using some signal processing.

VII. Acknowledgment

I would like to thank Professor Sudip Kundu, the supervisor of this research, for his guidance and support in all aspects of the project including components, technical and theoretical explanations, teaching concepts of biomedical instrumentation like ECG, pulse Oximeter, and various and other resources that helped develop the project.

VIII. References

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IX. Approval

Request for approval of my final year project report.

From: Sudip Kundu
To: aditya sharma

Dear Aditya,

You can submit the report.

Regards,
Sudip Kundu

From: aditya sharma
To: Sudip Kundu

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Respected sir,
kindly approve my project report for submission.
The report is attached to this mail.
Thank you
Aditya Sharma
(118EI0714)

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