KARNATAKA STATE COUNCIL FOR SCIENCE AND TECHNOLOGY, INDIAN INSTITUTE OF TECHNOLOGY, BANGALURU-560012

A Synopsis
On

An Energy Efficient Wearable Smart IoT System toPredict Cardiac Arrest

By

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Abstract

The prediction of heart failure survivors is a challenging task and helps medical professionals to make the right decisions about patients. Expertise and experience of medical professionals are required to care for heart failure patients. Machine Learning models can help with understanding symptoms of cardiac disease. However, manual feature engineering is challenging and requires expertise to select the appropriate technique. This project proposes a smart healthcare framework using the Internet-of Things (IoT) and machine learning that improves cardiac arrest patient's survival prediction without considering manual feature engineering. The smart IoT-based framework monitors patients on the basis of real-time data and provides timely, effective, and quality healthcare services to cardiac arrest patients.

A heart attack prediction system is also developed to predict the probability of heart attack from the available parameters. The novelty of the proposed work is that it takes the advantage of both the IoT and machine learning technology to monitor and predict the diseases. The proposed system is inexpensive too.

i. Introduction

Cardiac arrest is when the heart suddenly and unexpectedly stops beating. It occurs when the flow of blood to the heart is severely reduced or blocked. The blockage is usually due to a buildup of fat, cholesterol and other substances in the heart (coronary) arteries.

According to the World Health Organization, every year 12 million deaths occur worldwide due to heart disease.

The load of cardiovascular disease is rapidly increasing all over the world from the past few years. Many researches have been conducted in attempt to pinpoint the most influential factors of heart disease as well as accurately predict the overall risk.

Heart disease is even highlighted as a silent killer which leads to the death of the person without obvious symptoms. The early diagnosis of heart disease plays a vital role in making decisions on lifestyle changes in high-risk patients and in turn reduces the complications.

ii. Problem Definition/Problem Statement

The major challenge in heart disease is its detection. There are instruments available which can predict heart disease but either it is expensive or are not efficient to calculate chances of heart attack in human.

Early detection of cardiac arrest can decrease the mortality rate and overall complications. However, it is not possible to monitor patients every day in all cases accurately and consultationof a patient for 24 hours by a doctor is not possible.

How to reduce panic and notify the users about the early symptoms?
Which kind of microcontroller would satisfy the aims of the product by offering a better prediction system?

iii. Objectives

To design and develop an integrated smart IoT system with a low power communication module to discreetly collect heart rates and body temperatures using a smartphone without it impeding on everyday life.

To develop and implement a system that is able to track and record patient’s daily heart rates as well as to detect pinpoint signs of a heart attack.

To display warning notifications for patients who emit signs of an abnormal heart rate or signs of a heart attack.

iv. Methodology

The strength of our system relies on existing wireless communications to provide low power with maximum freedom of movement to users in their physical activity.

In addition, we have used small, light-weight smart IoT devices that are user friendly, like smartphones and the wrist-bands.

In our proposed system, the sensors allow to detect heart rate and temperature of a person even if the person is at home.

The sensors are then interfaced to a microcontroller that allows checking heart rate and temperature readings and transmit them over internet.

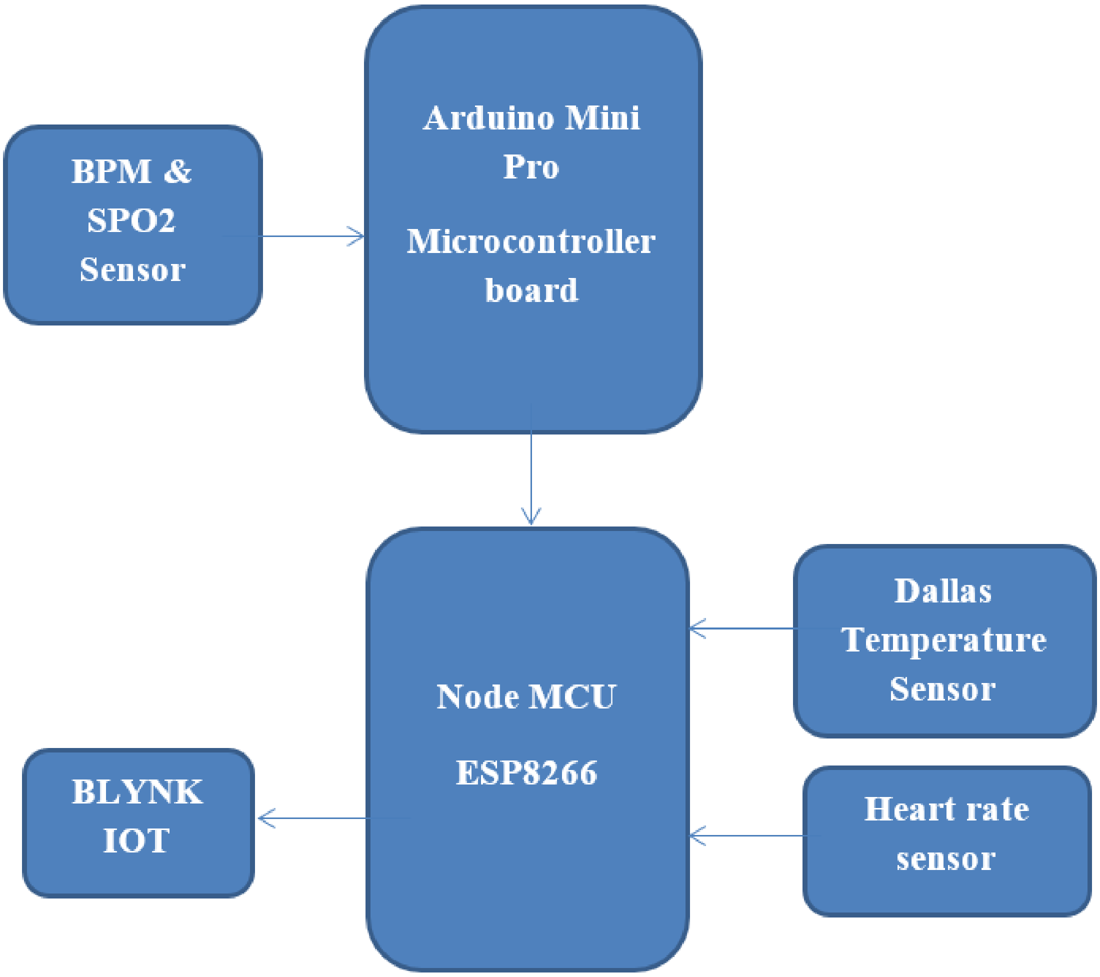

Figure 1: Components

After setting these limits, the system starts monitoring and as soon as patient heart beat goes above or below a certain limit, the system sends an alert to the controller which then transmits this over the internet and alerts the concerned users.

Whenever the user logs on for monitoring, the system also displays the live heart rate of the patient.

ECG Parameters

The P wave represents the depolarization of the left and right atrium and also corresponds to atrial contraction.

As the name suggests, the QRS complex includes the Q wave, R wave, and S wave. These three waves occur in rapid succession. The QRS complex represents the electrical impulse as it spreads through the ventricles and indicates ventricular depolarization. As with the P wave, the QRS complex starts just before ventricular contraction.

To determine abnormal heart patterns, we first establish a criterion for a healthy heart like heart rate,RR interval and ST segment.

A T wave follows the QRS complex and indicates ventricular repolarization. Unlike a P wave, a normal T wave is slightly asymmetric; the peak of the wave is a little closer to its end than to its beginning.

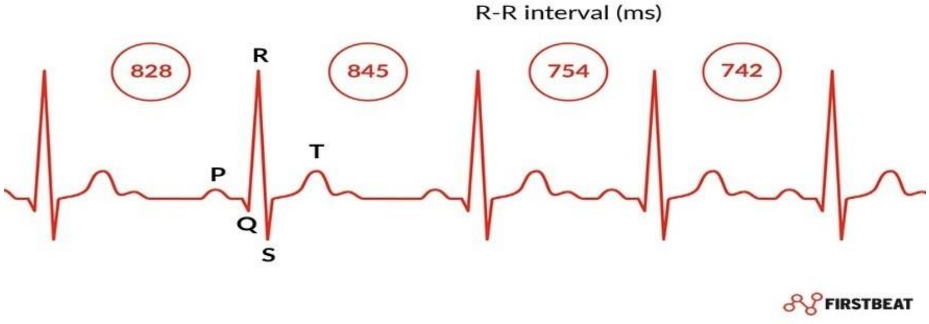

Figure 2: Sample ECG graph

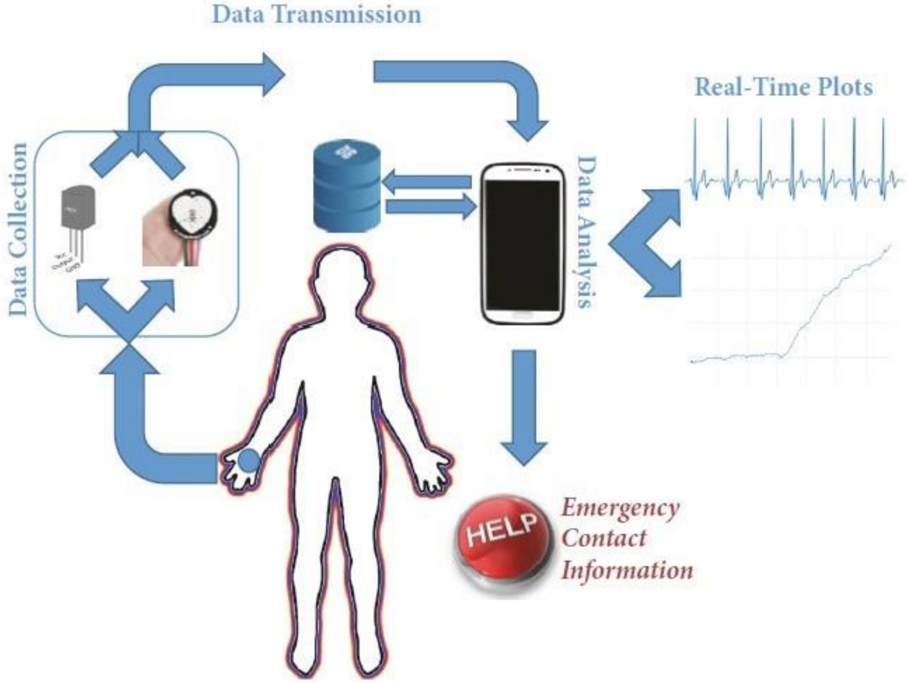

Figure 3: Flow diagram of the proposed system

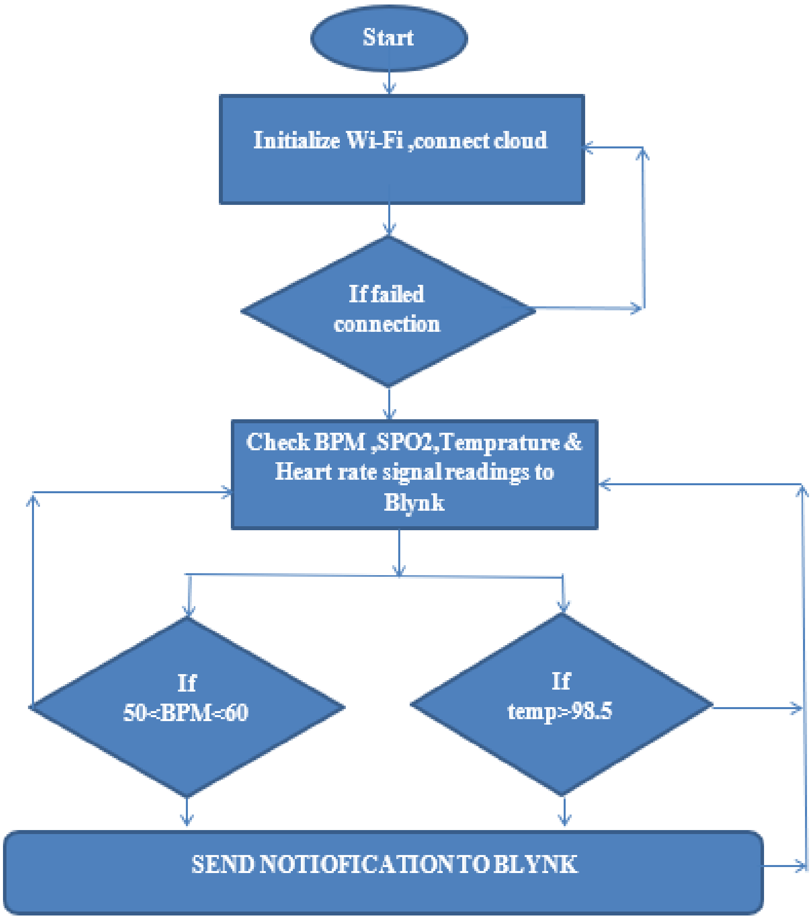

Figure 4: Sensor and Cloud Integration Flow Diagram

SOFTWARE PART

The software part of our project uses the Blynk IoT (Internet of Things) platform that allows users to remotely control and monitor their connected devices through a mobile app. It provides an easy-to-use interface and a variety of widgets that can be customized to suit specific project requirements. Here we are using it to process and visualize the data transmitted by the ESP8266 module from the hardware part.

The flow diagram (Figure 3.2) typically starts with initialization of Wi-Fi and connecting to the cloud which is achieved by connecting the hardware part to the Wi-Fi Hotspot. The algorithm reiterates the above process until there is a stable connection. Once the connection is established the sensors including BPM & SPO2 sensor, Pulse sensor and Temperature sensor gets activated and starts transmitting the data over the internet on to the cloud platform. Since we are using cloud platform to both collect the data and visualize while observing the data applied multiple conditions that are supports our case of detecting cardiac arrest which includes 3 different event triggering conditions.

First condition includes a warning based on temperature where the event is triggered if temperature is found to be above 100 F which sends a Warning Notification “HIGH BODY TEMPERATURE” sent to both host and any user that is required. Second condition includes a warning based on SPO2 (saturated oxygen level) where the event is triggered if SPO2 is found to be in between 80 to 90 percent of oxygen which sends a Warning Notification “LOW SPO2 LEVEL FOUND” sent to both host and any user that is required. Third condition includes a warning based on BPM (beats per minute) where the event is triggered if BPM is found to be in between 50 to 60 which sends a Warning Notification “LOW BPM LEVEL FOUND” sent to both host and any user that is required. The notification can be of different forms which includes Push notification, SMS notification, Email notification.

IMPLEMENTATION

The heart rate monitoring system is an important device that is used to monitor heart rate and temperature in real-time. The device is designed to be portable and convenient, with a Li-ion battery powering the system. The system is connected to a TP4056 charging module to ensure the battery is charged appropriately. The Li-ion battery used in the system is a rechargeable battery with a capacity of 2300 mAh providing a constant 3.7 V voltage. This makes it ideal for portable devices that require a reliable power source. The TP4056 charging module is used to ensure that the battery is charged appropriately, preventing overcharging or undercharging of the battery.

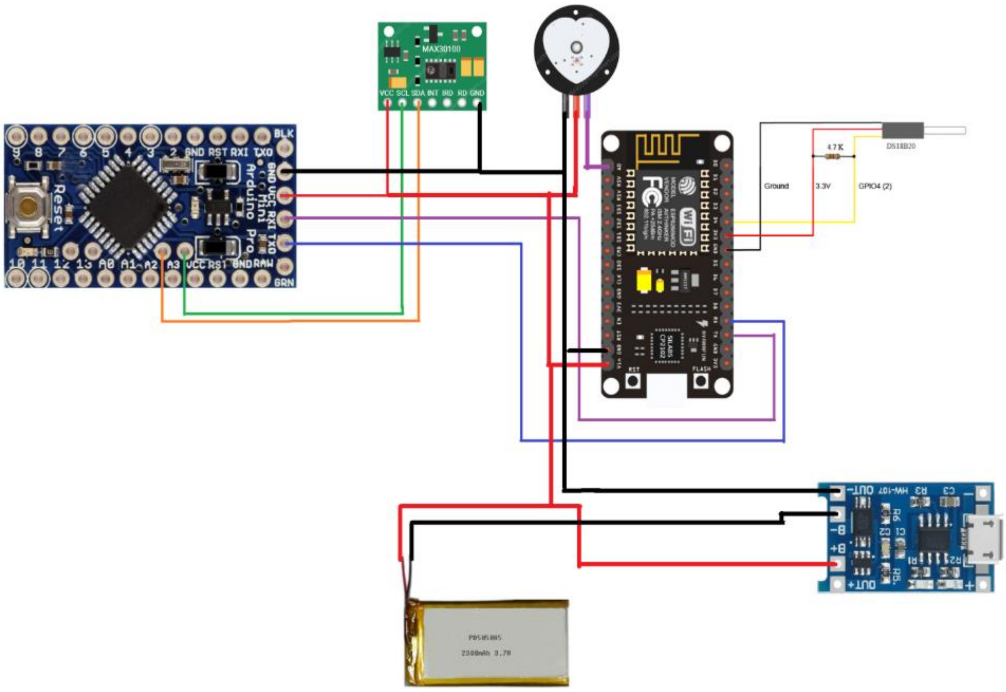
Figure 5: Circuit Diagram of System

The system consists of three sensors, a temperature sensor, a pulse sensor and a BPM & SPO2 sensor. The temperature sensor is connected to the digital pin (D3) of the Node-MCU, while the pulse sensor is connected to the analog pin (A0) of the Node-MCU. The Dallas Temperature Sensor is used for measuring the temperature, which operates using the 8 Bit One Wire Protocol.

As the Node-MCU only supports one I2C interface, an Arduino Mini-Pro is used to connect the BPM and SPO2 sensor. The BPM and SPO2 sensor are connected to the SDA and SCL pins of the Arduino mini–Pro. Data transfer between the Node-MCU and Arduino Mini-Pro is achieved using Transmitter and Receiver Pins.

The pulse sensor used in the system is an analog sensor that is connected to the A0 pin of the Node-MCU. The sensor detects the pulse rate and transmits the data to the Node-MCU for processing. The BPM and SPO2 sensor are highly accurate and reliable sensors for measuring heart rate and oxygen saturation levels. The SDA and SCL pins of the Arduino Mini-Pro are used to connect the sensors, which are then connected to the Node-MCU using Tx and Rx Pins.

v. Hardware and Software Requirements

Hardware:

- Arduino Mini Pro
- Pulse Sensor
- BPM and SPO2 Sensor
- Dallas Temperature Sensor
- ESP8266 Wi-Fi Module
- Node-MCU Breakout Board
- Breadboard
- Jumpers
- Li-ion Battery
- SPDT Switch
- TP4056 Charger Module

Software:

- Arduino IDE
- BLYNK IOT
- MC Programming Language: C

vi. Expected Results

In this project a real time heart rate monitoring and heart attack detection system is realized by using IoT and ML.

The developed system is intended to help detection of heart rate, body temperature, pulses of a person (of all age groups) even if the person is at home.

This system helps to detect heart rate, body temperature, pulses of a person even if the person is at home.

Therefore, the proposed system helps in predicting cardiac arrest in advance.

The heart monitoring system we have created is designed to be easy to use and accessible for all. We have incorporated user-friendly features such as customizable alerts and notifications, which can be set up to notify users of any abnormal heart rhythms or other concerning patterns. The system can also be integrated with mobile devices, allowing users to easily access and share their heart health data with healthcare providers or family members.

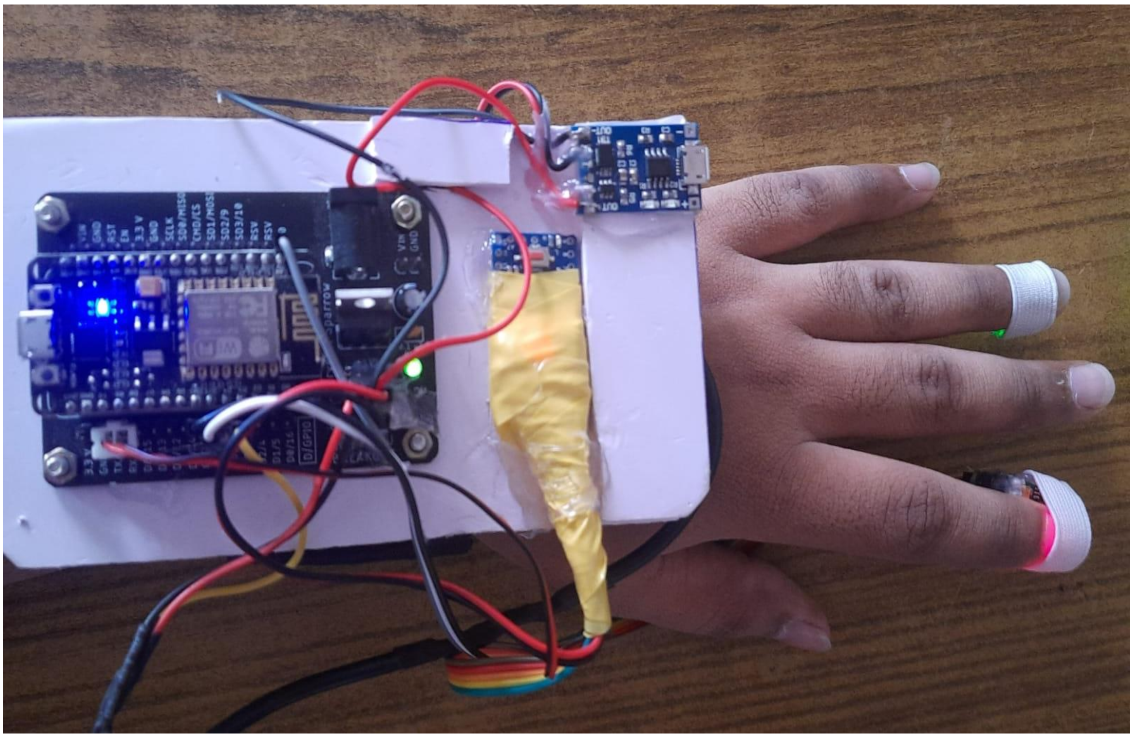

Fig 6: Wearable smart IoT device

The system was tested for heartbeat and temperature of multiple random persons and the results are tabulated. The table below shows the beats per minute (BPM), saturated oxygen level SPO2 and the temperature value (in Fahrenheit) of the tested person.

Sl No.	Name	BPM	SPO2	Temp
01.	Person A	76	95	96 F
02.	Person B	80	96	97 F
03.	Person C	68	96	96 F
04.	Person D	71	97	95 F
05.	Person E	55	92	99 F

Table 1: Calculated value of BPM, SPO2 and temperature

vii. Advantages and Limitations

Advantages:

Improves data driven clinical decision making

Helps patients improve self-management and care plan adherence

Cost of Care reduction for payers and providers

Reduces patient’s expenses and improves work productivity

Improves access to care

Improves patient experience and satisfaction

Limitations:

Prediction of cardiovascular disease results is not accurate.

Data mining techniques does not help to provide effective decision making.

Cannot handle enormous datasets for patient records.

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