Design and Development of IoT Based Health Monitoring System

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Abstract: This paper presents the design and development of internet of things (IoT) based health monitoring system. Nowadays, scientists have invented electronic devices through which all the health indices of the body can be measured very conveniently within a short time. The internet of things (IoT) in healthcare industry provides improved patient health monitoring and enables doctors and healthcare staffs to obtain more accurate measurement of health indices. This paper aims to explain the designing and development of an appropriate monitoring system that can measure a patient's body temperature (using GY906 temperature sensor), oxygen saturation level, heartbeat rate (using Max30100 sensor) and electrocardiogram (ECG) (using AD8232 ECG sensor). This system will especially benefit rural patients suffering from corona virus, hypertension, diabetes, cardiac problems etc. in developing countries like Bangladesh, where it is often difficult to receive immediate health services or obtain various body tests. Traditional medical equipment are expensive to afford, and regular medical checkup may not be possible for rural people due to various reasons. This IoT based system will be user friendly and will simplify the utilization of complicated medical devices at a minimum cost. Apart from the sustainability in the context of finance, patients will have easy access to personal healthcare. The use of these devices as support tools by the rural people undergoing certain health conditions could have a significant impact on their own lives.

Keywords: COVID-19, Internet of things, Temperature sensor, Pulse oximeter sensor, ECG sensor, Heartbeat Sensor.

I. INTRODUCTION

The clinical area is making deep use of IoT based devices. IoT based health monitoring system offers us significant benefits from contemporary medicine. The Arduino uno, ESP 8266 node mcu, Temperature sensor (GY906), heartbeat sensor and pulse oximeter sensor (Max30100), ECG sensor (AD8232) is used as hardware in this system and Arduino IDE was used as software. This software is used to interface sensors with Arduino. It works by activating the sensors and display results. The sensors used in this health monitoring system collect the health status of the patient and display it on the computer web server. This system is small, easy to use and cost effective. The patient's body temperature (using GY909 temperature sensor), oxygen saturation level and heartbeat rate (using Max30100 sensor), electrocardiogram (ECG) heart's rhythm can be measured using this system and electrical activity (using AD8232 ECG sensor) and they can see the patient's test results on the computer webserver [1]. The work of IoT is to link computers to the internet using sensors and networks [2]. An important indicator for the health of the human body is the heartbeat rate. Heartbeat rate is measured by the number of beats per minute on the clock [3]. It also known as the pulse rate. Normal heart rate range is 60 to 100 beats per minute (bpm) in case of healthy people. This rate is 70 bpm for the typical restful heart for adult males and 75 bpm for adult females [4]. It has been observed that the heart rate of people suffering from various diseases like asthma, hypertension, heart disease, Chronic Obstructive Pulmonary Disease etc. changes continuously. Also added now are people affected by COVID-19, whose heartbeat rate changes very quickly every now and then [1]. Covid-19 patients produce irregular heartbeats. If someone is sick, the diseases can be linked with some physiological parameters in human body like heartbeat rate, body temperature, blood pressure etc. [5]. There is strong evidence that patients suffering from COVID-19 are getting heart problems, whether it's a direct effect of the infection or of a systemic infection," says Kai-Uwe Lempertz, a global clinical development manager at GE Healthcare. He describes how viral pneumonia can "jump over" to the heart, causing myocarditis or heart muscle inflammation [6]. ECG is very important for heart patients to find out any irregularity. Heart's rhythm and electrical activity is known through ECG. Generally, girls aged 12 years and older have a higher heart rate than boys of same age. Human body temperature is the sum of human body heat and the heat radiated from human skin. It is scientifically determined. Human body temperature depends on various factors such as environmental temperature, age, diet etc. A normal healthy person's temperature is usually between 97.8 °F (36.5 °C) and 99 °F (37.2 °C) [7]. This IoT system uses GY906 sensor to detect human body temperature. Anyone can measure their body temperature at home using the same. The amount of oxygen in the blood is another important factor in the human body. If the amount of oxygen in the blood plunges below normal level, people may die. This system uses a pulse oximeter sensor to measure the oxygen level in the blood. In the pulse oximeter, red and IR (Infrared) LEDs (light emitting diode) sent signals to the photodiode. An equation or relationship between the ratio (R) of signals (red and IR) received by photodiode with the oxygen saturation value (SpO2) needs to model the value of blood oxygen saturation [8].
In the paper, the author measured the temperature using two temperature sensors (MAX30100 and Lm35). This result can be seen only on computer web server [16]. In the paper, the author did heart rate, body temperature, diabetes test but did not diagnose oxygen level in blood and ECG. The result can be seen on the mobile application and on the wearable device [17]. In the paper, the author has determined the heart rate, body temperature and the results can be seen on the computer website [18]. In the paper, the author has determined the heart rate, body temperature, respiration rate and the results can be seen in the mobile application [19].

This system will help all classes of people, but it will be more beneficial for those who cannot afford regular check-up such as body temperature, blood oxygen level, ECG, heartbeat. It is not only cheaper but also easy to use. Our system is useful for people of all ages. Through this system, the patient's body temperature, blood oxygen level, number of heart beats in 1 minute, heart condition can be determined through ECG, all these test results can be seen on the computer web server. Later, in the future we can create a web application where the patient's test results with date and time can be displayed. Our goal is to create a system that provides accurate test reports at a low cost. That will be very helpful during the pandemic and the post COVID-19 situation.

II. METHODOLOGY

The process of analyzing the complete system of any system is called methodology.

A. *Sensor Interfacing*

- Configuring the inputs pin for sensors in microcontroller.
- Connecting the input sensors oximeter, ECG, heartbeat, temperature to Arduino for monitoring the patient conditions.
- Writing the code using Arduino ide software.

B. *Output:*

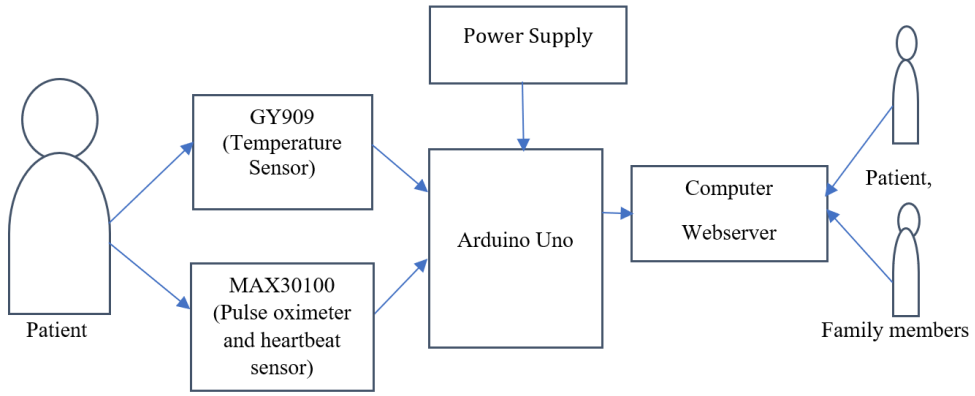
- Then patient/family members can see the result of the sensors on the computer webserver.

C. *The Hole System Interface With IOT Module*

- In these proposed system, IoT (internet of things) can be used to monitor patient data worldwide via the Internet [9].
- The diagram of proposed system model: Two models are provided in this system 1(A) and 1(B). Because the graph obtained by using the ECG sensor is quite large. So, two models are used for ease of understanding.

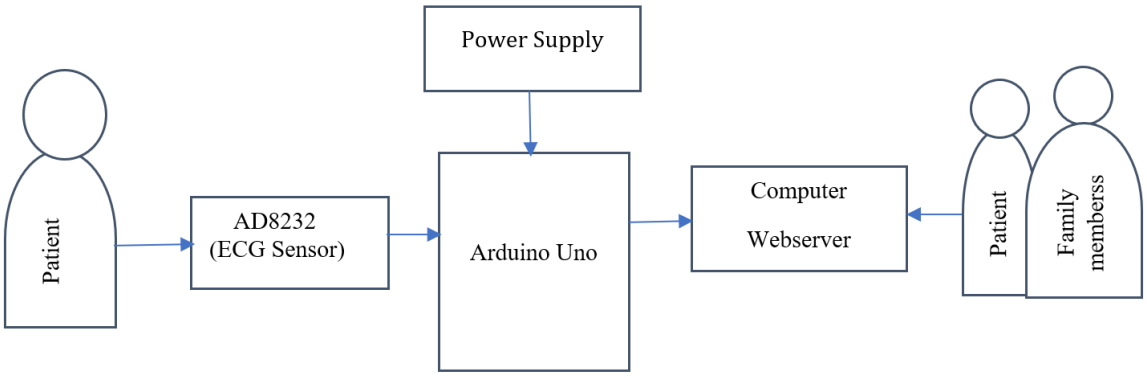
Two sensors are used in Model 1(A) they are Temperature sensor, Pulse oximetry and heartbeat Sensor.

Figure 1: Proposed system model 1(a)



A sensor has been used in Model 1(B); they are ECG Sensor.

Figure 2: Proposed system model 1(b)

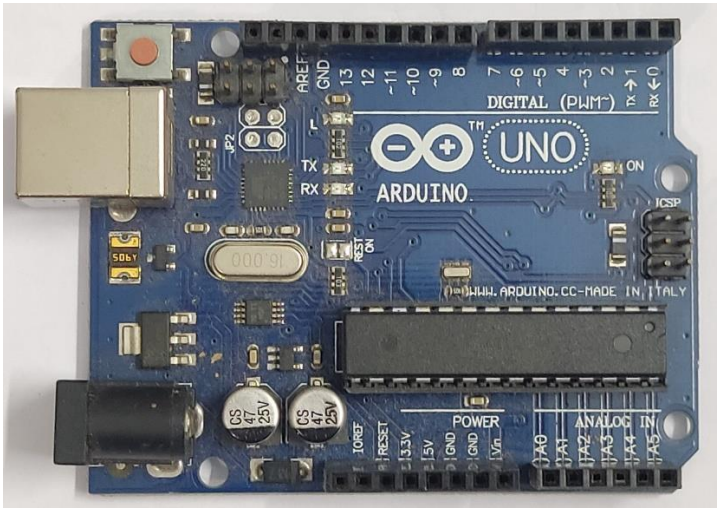


III. HARDWARE REQUIREMENT

A. *Arduino Uno*

Arduino Uno is used as microcontroller in this system. Because it's an open-source electronics platform. This platform is user friendly and easy to use. Arduino has 14 input output pins those are digital and a USB cable that standards A-B USB cable [10]. Anyone can guide the board by sending a bunch of directions to the microcontroller on the board. To do so anyone can use the Arduino programming language (in view of wiring), and the Arduino Software (IDE), based on Processing. It is used for communicating with a computer, microcontroller, another Arduino board is less expensive than another microcontroller platform. Arduino software (IDE) runs on Windows, Mac, Linux operating system.

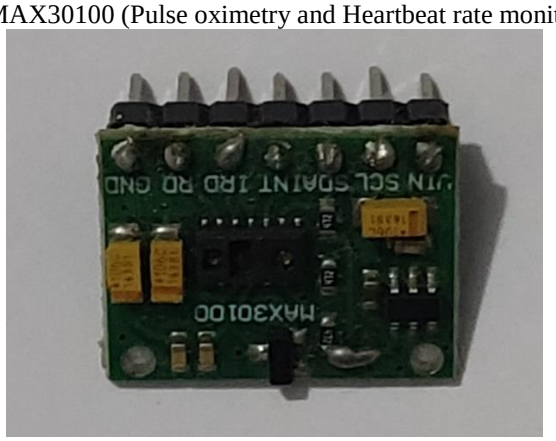
Figure 3: Arduino Uno



B. ***MAX30100 (Pulse oximetry and Heartbeat rate monitor sensor):***

Max30100 is used in this system. It is a compact sensor. The Max30100 sensor is a heart rate monitor and pulse oximeter sensor. Through it, the heartbeat rate, and the amount of oxygen in the blood can be determined. The microcontroller uses the 12C interface to communicate with this sensor. After connecting this sensor with the microcontroller, it works by sending infrared light to the capillaries in finger, foot or earlobe after patient's finger is placed on the sensor. Then it measures how much light is reflected off the gases [11]. This sensor is very helpful for today's (covid-19) situation. Cause anyone can measure the oxygen level in the blood on staying home. At the same time, this sensor measures the heartbeat rate and to measure changes in blood volume [14]. The heartbeat sensor is created based on the plethysmography theory. When this sensor is working, the beat LED flashes in unison with each heartbeat. The digital output is directly connected to the microcontroller to measure the beat rate per minute. The rule of light modulation by flowing the blood through finger at each heartbeat. In every heartbeat, the detector signal is converted to electrical pulse [15].

Figure 4: MAX30100 (Pulse oximetry and Heartbeat rate monitor sensor)



In this system,

- A finger, earlobe, or toe is placed in the pulse oximetry and heart rate monitor sensor.
- Small light emissions go through the blood in the finger, estimating the measure of oxygen and determines the number of heart beats.
- After that, it shows result in the computer webserver.

C. ***GY906 (Tempertaure sensor)***

GY906 is a body temperature sensor. This sensor is used in this system. This temperature sensor is used for measuring the temperature of the body. Maintaining the temperature of the body is very important for a safe life. The size of this sensor is small. The usage method is very simple. The cost of using this sensor is low. Can be easily intrigared. If the body temperature is high in that case the result is heat stroke, dehydration and death if it is not treated. If the temperature of the body is low in that case the result is hypothermia and death if it is not treated [12].

Figure 5: GY906 (temperature sensor)

In this system,

- A finger is placed in the temperature sensor and temperature sensor sense the body temperature.
- After that, it shows result in the computer webserver.

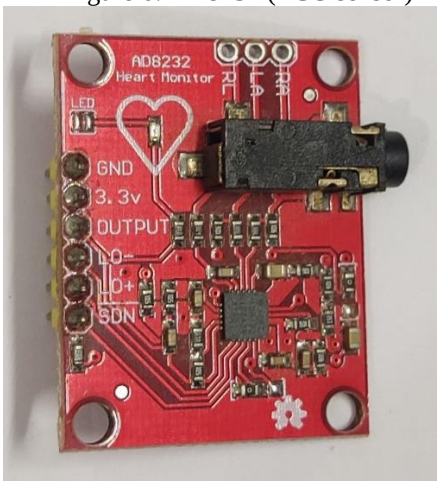
D. ***AD8232 (ECG sensor):***

Electrocardiogram (ECG) sensor is one of the most important tools in covid-19 situation. It is designed to extract, amplify, and filter small biopotential signals in the presence of noisy conditions, such as those created by motion or remote electrode placement. Covid-19 patients produce irregular heartbeats. That's why we are using ECG sensor (AD8232) in this proposed system. It includes 3 electro pads, which can be placed RA, RL, and LA. Full form of RA, RL and LA are RA=Right Arm, RL=Right Leg, LA=Left Arm. It has two analog filters; one is high pass filter with a cut off frequency of 0.48Hz and another is low pass filter with a cutoff frequency of 40Hz to achieve the required bandpass filter [12].

In this system,

- ECG sensor has 3 electro pads. These electro pads are placed in the human body. The data is taken but the results obtained from the ECG cannot be seen on the LCD display. Because the graph obtained from ECG is much larger.
- It shows result in the computer webserver.

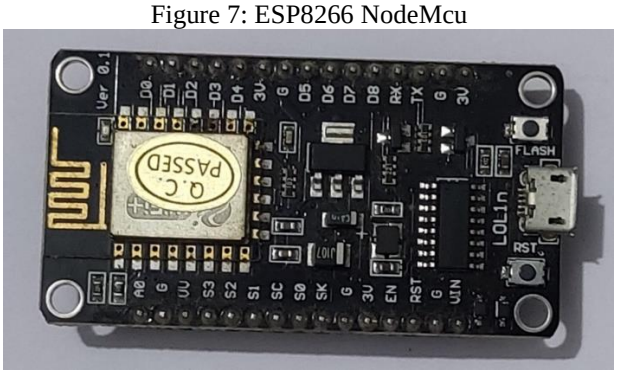
Figure 6: AD8232 (ECG sensor)



E. ***The ESP 8266 NodeMcu:***

This system uses using Wi-Fi with ESP8266 NodeMcu can be seen on computer web server. The ESP8266 NodeMcu works as the core of the system while MAX30100 and GY-906 sensors are in a slave master I2C connection with the NodeMcu. The NodeMcu uses the local WIFI to send data to the server. The server continuously updates the sensor data every second sent by the NodeMcu.

Figure 7: ESP8266 NodeMcu



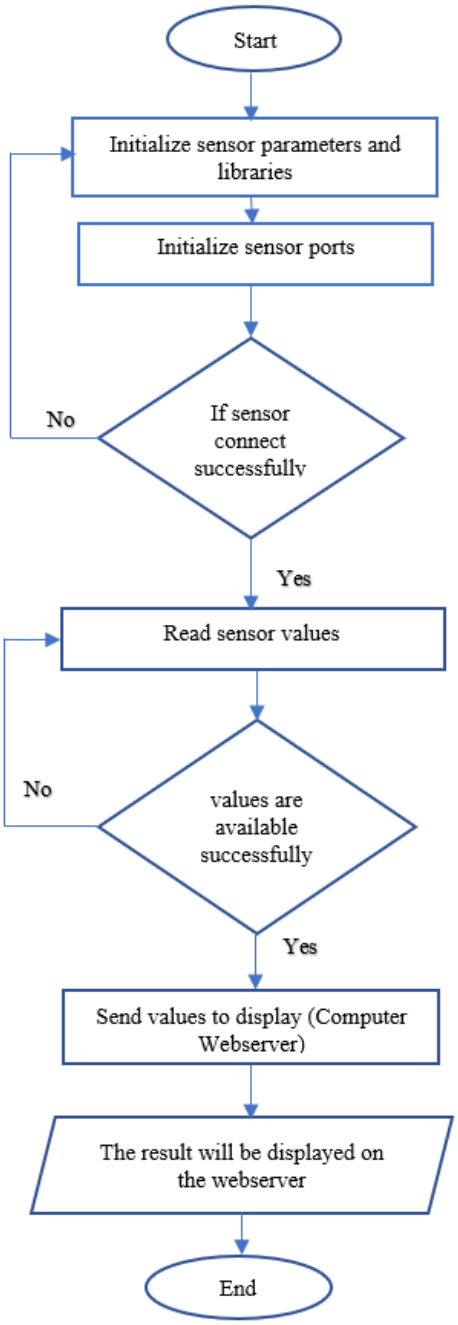
IV. SOFTWARE REQUIREMENT

Arduino IDE Software:

Arduino is software from which developers benefit a lot. This software uses Java programming language. This helps developers to control all functions of Arduino Uno [20]. It is an open-source platform. It is used to make gadgets. It consists of both the physical circuit board and the programming technology that runs serially on the PC [21].

V. FLOW CHART

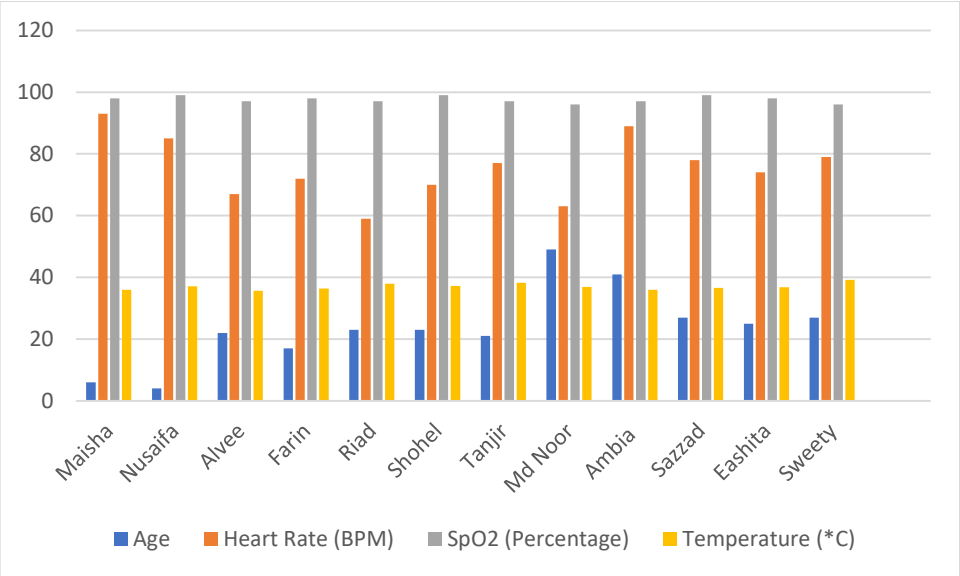
Figure 8: Flow Chart



VI. RESULT

This complete system has temperature sensor, pulse oximetry and heartbeat rate sensor, ECG sensor connected to Arduino. Arduino is connected to PC via cable which is connected to USB port. which will help the system to run. When all the connections are successfully completed, the data is uploaded to the Arduino and then the system starts working, displaying the measured data on the Arduino IDE (Integrated Development Environment) platform and on the computer web server. This system uses using Wi-Fi with ESP8266 NodeMcu can be seen on computer web server. The ESP8266 NodeMcu works as the core of the system while MAX30100 and GY-906 sensors are in a slave master I2C connection with the NodeMcu. The temperature of the patient is recorded in Celsius and sent to the NodeMcu by GY906. Likewise, the SPO2 percentage and heartbeat (BPM) of the patient measure by the MAX30100 sensor and sent to NodeMcu. The NodeMcu uses the local WIFI to send data to the server. The server continuously updates the sensor data every second sent by the NodeMcu. The Arduino Uno board is connected via analog port to the AD8232 and plots a graph of the patient ECG signal on the serial plot of Arduino IDE. We randomly measured the heart rate, body temperature, blood oxygen level percentage of 12 people of different ages. Below is shown in graph form.

Figure 9



CONCLUSION AND FUTURE WORK

The design and development of a health monitoring system using IoT is presented in this study. The system developed in this paper uses Arduino as the microcontroller. Through IoT based devices, health conditions such as temperature, heartbeat rate, blood oxygen level, heart condition through ECG can be easily known, which can help in controlling their health over time. The health test result can be seen on Arduino ide platform, and the result obtained using Wi-Fi with ESP 8266 nodemcu can be seen on computer web server. They can send these health parameters to the doctor to know about their health condition. IoT based monitoring systems are now more preferred in terms of health. Elderly patients, asthma patients, diabetic patients, Covid patients, also patients with various diseases can easily know about their health at home through our system.

This system can be further improved in the future. The results obtained by using the sensors in this system are only visible on the Arduino IDE platform and the computer web server. In the future, the result will be sent to the app via Bluetooth, and if the results of the health test are not normal, an alert message can be sent to the relative of the patient. The sensors used in this system can be further improved, and new sensors can be added. New algorithms can be added to the entire system for system security.

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