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Original Article

IoT-Based Smart Health Monitoring System for Efficient Service in the Medical Sector

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Abstract - *This paper demonstrates that the IoT-based system in health monitoring is considered to provide better treatment to sick people by improving the healthcare system. This paper offers remote healthcare monitoring systems that are easy to use, and wearable sensors, smartphones, and advanced technologies are rapidly developing. This device can continuously monitor the patient's heart rate, temperature, oxygen saturation, and other fundamental room elements. This project offers a 24-hour monitoring and control tool to check the patient's condition and store the report on a cloud server using a Wi-Fi module for remote communication. This project will be an excellent achievement for the medical sector.*

Keywords - *IoT, Smart Monitoring, Health, Remote, Communication.*

1. Introduction

Health is always a top priority in every technological development that makes the human race. The recent coronavirus outbreak that partially destroyed China's economy illustrates how spirited health care has developed [1]. It is always better to monitor these individuals using remote health monitoring technologies in locations where the disease is widespread. Therefore, the current response is an IoT-based health monitoring system. An arrangement for remote patient monitoring allows for observing patients outside typical clinical settings (such as at home), broadening access to human services offices while reducing costs[2]. Creating and implementing an intelligent patient system is the primary goal of this project. The medical facility would not be within easy reach of the locals in most rural locations. So typically, the people's hospital stays and diagnostic testing procedures [3]. Human bodies use temperature and pulse recognition to examine and comprehend overall health. The sensors are connected to a microcontroller that is interfaced with an LCD panel with a remote connection that can exchange alarms. The framework immediately alerts the client about the patient's status through IoT. It indicates subtle parts of the pulse and temperature of the patient live in the web if the framework discovers any abrupt modifications in comprehending heartbeat or body temperature. IoT established a well-being framework in this system [4]. So, the IOT-installed passive well-being monitoring system successfully uses the web to display quiet well-being metrics and save persistent time. The health of mine workers, merchant marine employees, and hospital patients kept under observation can be monitored using this technique.

The Wi-Fi technology is implemented in this project which sends the data from the Sensor to the web server to control the control unit. This technology is necessary for a few situations. Modern technology like machine learning (ML) & artificial intelligence (AI) can help advance this module due to its adapted learning capabilities that can transfer the patient's medical logs to another location. This track record can be kept for future reference. Clinical images are easily saved, shared with doctors, and recorded for future reference.

2. Literature Review

With the incidence of new variants of coronavirus, many countries, including Bangladesh, now have to pay high healthcare prices and unnecessary tests for patients [5]. So, an IoT health monitoring system is ideal for such a presidential response. In the field of IoT systems in medical care, studies are currently being conducted on raw data from sensors in wireless network-connected systems to provide clinical information to aid in diagnosing and treating life-long diseases [6]. Accordingly, today's health monitoring systems, including ECG, pulse, and blood pressure sensors, are becoming more efficient. The smart health system allows us to store medical information mechanically through Wi-Fi entitled devices. It holds patients' medical records, analyses their health status information, and advises us on good tips and services primarily based on health analysis. It can also provide us with warnings regarding health risks [7]. It also allows us to monitor health reports as it connects with various health service providers such as companies, labs, nursing homes, healthcare, and tale-consulting services [8]. It consists of three utterly different health monitoring systems. The blood pressure level and smart ECG monitor support health monitoring by the IoT platform, which helps providers collect, store, and analyze medical knowledge and alerts patients of significant disease symptoms [9]. It primarily allows us to select and customize individual services based on the patient's health status.

2.1. Blood Pressure

This is a suitable device titled deliberation and blood pressure Scale, which allows us to record medical knowledge mechanically and allows patients, and medical health consultants, to remotely access this completely different knowledge along with the patient's profile and healthy organs [10].

2.2. Smart ECG

It helps to collect, store and share the health data of vulnerable people. It can always monitor the patient's health conditions [11]. This device records data to the Web Server once and updates the data frequently depending on the patient's health. Smart ECG is a related embrace website and mobile app that will help to analyze many of the health data that capture. It has multi-app property options to share data with anyone [12]. The ECG sensor-based model is an exploratory study of product innovation in the automotive sector. Smart ECG helps us store and organize data and offers this data to the doctor.

2.3. Benefits of IoT-based Healthcare Systems

IoT-based healthcare systems offer several potential benefits, including improved patient outcomes, reduced costs, and increased efficiency. One of the key advantages of IoT is the ability to collect and analyze real-time data from various sources, including wearables, sensors, and mobile devices [13]. This data can be used to provide personalized care and interventions, allowing healthcare providers to make more informed decisions about patient care.

Another benefit of IoT-based healthcare systems is the potential to reduce costs by improving efficiency and reducing waste [14]. By automating certain processes, such as inventory management and patient monitoring, healthcare providers can reduce the time and resources required to manage these tasks, freeing up resources to focus on patient care.

IoT-based healthcare systems can also improve patient safety through real-time monitoring of vital signs and other health metrics [15]. It can alert healthcare providers to potential issues before they become serious, allowing for more timely interventions and better outcomes.

2.4. Challenges of IoT-based Healthcare Systems

While IoT-based healthcare systems offer many potential benefits, several challenges must be addressed. One of the key challenges is ensuring the security and privacy of patient data. With so much sensitive information being collected and transmitted, it is essential to have robust security measures in place to prevent unauthorized access.
Another challenge is ensuring the interoperability of different devices and systems. With so many kinds of devices and platforms in use, it can be difficult to ensure that data is being collected and transmitted in a consistent and standardized manner.

There is also a challenge in ensuring that healthcare providers can use the data collected by IoT devices effectively[16]. With so much generated data, it can be difficult to sift through and identify the most relevant information. It is, therefore, important to develop tools and technologies to help healthcare providers make sense of this data and use it to inform patient care.

2.5. Current State of the Art in IoT-based Healthcare Systems

There are several IoT-based healthcare systems currently in use or development. These systems vary in Design and functionality, but all aim to leverage the power of IoT to improve patient outcomes and reduce costs.

One example of an IoT-based healthcare system is the Philips HealthSuite platform. This platform integrates data from various sources, including wearables, medical devices, and electronic health records, to provide a comprehensive view of a patient's health [17]. The platform uses advanced analytics to identify trends and patterns in the data, allowing healthcare providers to make more informed decisions about patient care.

Another example is the GE Health Cloud, which provides a platform for collecting and analyzing data from various medical devices. This platform uses advanced algorithms to identify patterns and trends in the data, allowing healthcare providers to identify potential issues before they become serious.

Some IoT-based systems also focus on specific areas of healthcare, such as diabetes management or remote patient monitoring [18]. These systems typically include a variety of sensors and wearables that collect data on a patient's health, as well as software tools for analyzing and presenting this data to healthcare providers.

2.6. Future Directions for IoT-based Healthcare Systems

While IoT-based healthcare systems have already demonstrated significant potential, there is still much room for development and improvement [19]. One area likely to see continued growth is using artificial intelligence (AI) and machine learning (ML).

The Internet of Things (IoT) has revolutionized how we interact with technology, providing unprecedented connectivity between devices and enabling real-time data collection and Analysis. One of the most promising areas for the application of IoT is in the healthcare field, where it has the potential to improve patient outcomes, reduce costs, and increase efficiency[20]. This literature review will examine the current state of the art in IoT-based healthcare systems, exploring their benefits, challenges, and potential for future development.

3. Project Objective

There are various kinds of accomplishments to be achieved by this project, which will be great for the modern medical sector, such as:

- Monitoring the patient's condition remotely.
- The patient's ongoing restraint.
- This project is aimed at modernizing and developing a smart technology in health.
- This more sophisticated device—utilized to create a more contemporary living level—refers to automatic and electronic control.
- Take some challenges to monitor patient condition and store data in the online database.
- Direct access to skilled medical personnel at any time and location via a contemporary communications network.

This project ensures that the health industry takes advantage of smart technologies, which refer to automatic and electronic control with improved healthcare management and reduction of healthcare costs also.

4. Methodology

This project designed the block diagram structure of the project as per the proposed system. The project considered completed all programming (Appendix), component installation of this project, and system test run. This project used many electronic components to develop the Design, making it as simple and cost-effective as feasible. Moreover, the system is easy to operate and can be customized according to the patient's needs. Setting up or modifying a component must be compatible with the available software. Each electronic component used in this system was individually programmed and tested for safety measures and compatibility with the correct driver. Each control unit is programmed separately with both the NodeMCU and the Arduino Uno using the Arduino Software.

4.1. Planning and Analysis

This project aims to develop and deploy an IOT-based health monitoring system. Electronic sensors are used in this system for metering the patient's heart rate and electric heart signal. The control unit calculates the sensors' values and the estimated data displayed on the LCD monitor. Project objectives and scope will be defined in system planning.

Finally, while checking the entire setup, observe the cause of this project's delayed Analysis in the system's analysis phase, which will interview the potential users of the proposed solution to gather practical steps for the proposed method. Next, system requirements such as hardware, software, and user requirements will be extracted based on the system requirements.

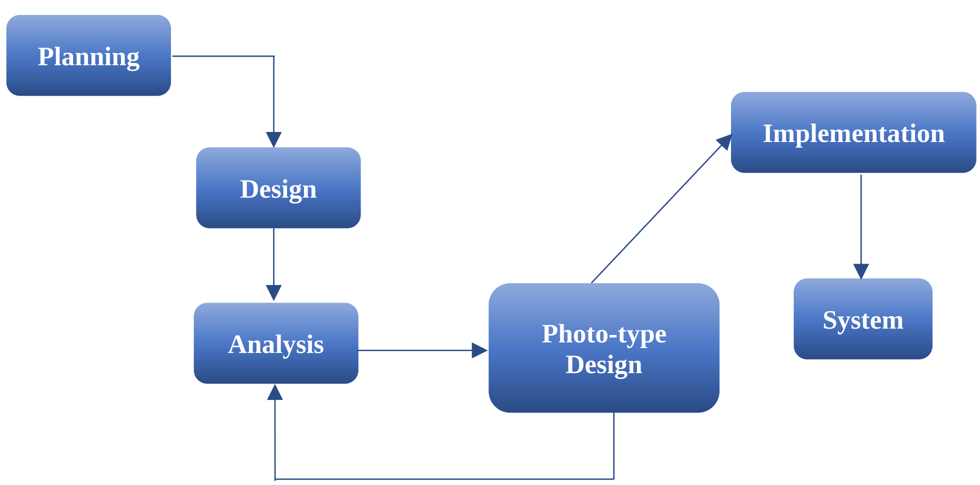

Fig.1 Methodology

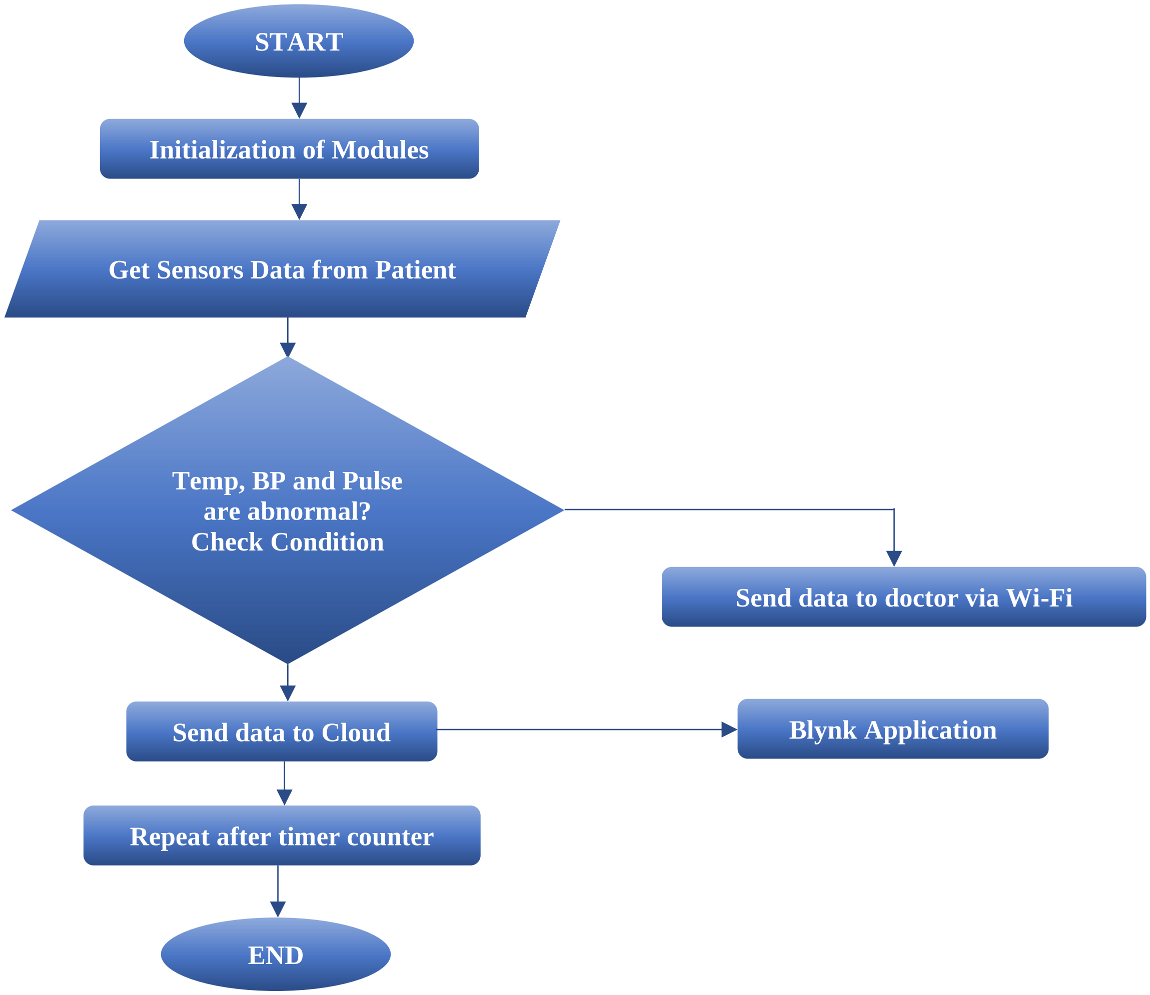

Fig. 2 Flow chart of the Project

4.2 Flow Chart

The bottom showed the figure consists of the flowchart, which demonstrates the workflow of the automated monitoring system.

4.3. Prototype Design

In this phase, the task combines each module to complete a final system prototype implemented in the previous step. The completed prototypes will be made for the testing system used for testing and evaluation purposes in the university lab. At this point, it will respond, clarifying its need. The results obtained through this feedback and testing will continuously modify the prototypes according to the users' requirements until it reaches near perfection.

4.4. System Planning

First, System Planning has identified the system problem for the project plan's high-level development and selected its requirements to solve it. Additionally, the analysis techniques are used to explain the strengths, weaknesses, limitations, and opportunities of the basic needs for the proposed solution. After that, a project timeline is created to clearly understand what steps should take per the project life cycle. The project's web dashboard is usually a graphical design that shows a long bar labeled with dates alongside itself, and it typically tags where the events happened in the timeline.

4.5. System Analysis

In the system's analysis phase, interview the potential users of the proposed solution to gather valuable steps for the proposed method. Next, system requirements such as hardware, software, and user needs will be extracted based on the system requirements.

4.6. Requirements

Here is an idea of all the materials used to start the project. Knowing all the software and hardware specifications used in the project is essential. The components we are using are as follows:

4.7. Software Requirements

- Arduino IDE
- Proteus simulation software

4.8. Mathematical Model

A mathematical model of an IoT-based health system can be derived by considering the following components:

4.8.1. Sensors

These devices collect health data from patients, such as heart rate, blood pressure, temperature, and oxygen saturation. Let Si (t) be the i-th Sensor's value at time t.

4.8.2. The Communication Network

The communication network connects the sensors to the cloud or central server, where the data is processed and analyzed. Let C (t) be the status of the communication network at time t, where C (t) = 1 if the network is available and 0 if it is not.

4.8.3. Cloud/Server

This is where the health data is stored, processed, and analyzed. Let H (t) be the health data stored in the cloud/server at time t.

4.8.4. Algorithms

These mathematical models analyze health data to detect abnormalities or anomalies. Let A(t) be the algorithm's output at time t.

4.8.5. Actuators

These are devices that respond to the Analysis of the health data, such as notifying healthcare providers or initiating emergency responses. Let Ac(t) be the status of the actuator at time t, where Ac(t) = 1 if the actuator is activated and 0 if it is not.

Based on these components, the mathematical Model can be expressed as follows:

$$Si(t) \rightarrow C(t) \rightarrow H(t) \rightarrow A(t) \rightarrow Ac(t) \quad (1)$$

The arrows represent the flow of data and information between the components.

The Model can be further refined by specifying the functions that relate to the components. For example, the function that relates the sensor data to the cloud/server can be expressed as:

$$H(t) = f(S1(t), S2(t),...,Sn(t), C(t)) \quad (2)$$

Where n is the total number of sensors and f is a mathematical function that transforms the sensor data into a form suitable for Analysis.

Table1. Hardware Components

SL/NO	Instrument	Quantity
01	NodeMCU Micro-controller	1
02	Arduino Board	1
03	LCD Display	2
04	Pulse Sensor	1
05	LM35 Temperature Sensor	2
06	ECG Sensor	1
07	Oxygen Chamber	1
08	L293D Driver Module	2
09	PCB Board With Black Line	3
10	Power Supply (12v)	1
11	Transistor (BC547)	4
12	Potential Meter (10k)	4
13	Resistor (100ohm, 1k, 10k)	10
14	Voltage Regulator (7805)	1
15	Jumper Wire (Male To Female)	20
16	Lithium Battery Pack (Cell)	4
17	Glue Stick	2
18	Air Motor	1
19	Card Board	1
20	Glue Gun	1
21	Relay Module	2
22	Buck Converter (LM2596)	1
23	Glass Chamber	2
24	Plastic Pipe	6
25	Air Humidifier	1

Similarly, the function that relates the health data to the output of the algorithm can be expressed as:

$$A(t) = g(H(t)) \quad (3)$$

Where, g is a mathematical function that processes the health data to detect abnormalities or anomalies.

Finally, the function relates the output of the algorithm to the status of the actuator can be expressed as:

$$Ac(t) = h(A(t)) \quad (4)$$

Where, h is a mathematical function determining whether the algorithm output warrants activating the actuator.

Overall, the mathematical Model of an IoT-based health system provides a framework for understanding how the various components interact to enable remote health monitoring and care delivery. The Model can be used to optimize system performance, improve patient outcomes, and reduce healthcare costs.

5. System Design

5.1. Project Overview

The project envisions the IoT as a type of intelligent heterogeneous network. It can also communicate and share data over the Internet. In the developing country's traditional healthcare models, patients must attend a medical practitioner or doctor daily. Both patients and medical staff find this traditional method disadvantageous. The project aims to develop an IoT-based health monitoring system with specific sensors that can read different health parameters and display the health data on an LCD module by attaching them to the patient's body in real-time. Patient health data can transfer data to the cloud to store it securely and update this data to the prescribing doctor for treatment. This paper describes a yacht-based digital hospital healthcare device developed using a blood oxygen sensor, NodeMCU, pulse rate sensor, ECG sensor, Arduino Uno, and temperature sensor. As a result, the Internet of Things-based systems can improve medical care while reducing patient costs by automating continuous data collection and Analysis. The microcontroller measures body temperature, pulse rate, ambient temperature, and oxygen saturation. The full-fledged prototype of the sensor-based health monitoring system would show the output values of the sensors calculated and displayed on an LCD, making them visible to patients as well.

The IoT platform permits authorized users to enter these data from the cloud. The patient's health situation is diagnosed based on the values received. A medical professional will make the diagnosis of the patient's health. The doctor can recommend the right action and prescribe the prescriptions from a distance.

5.2. Block Diagram

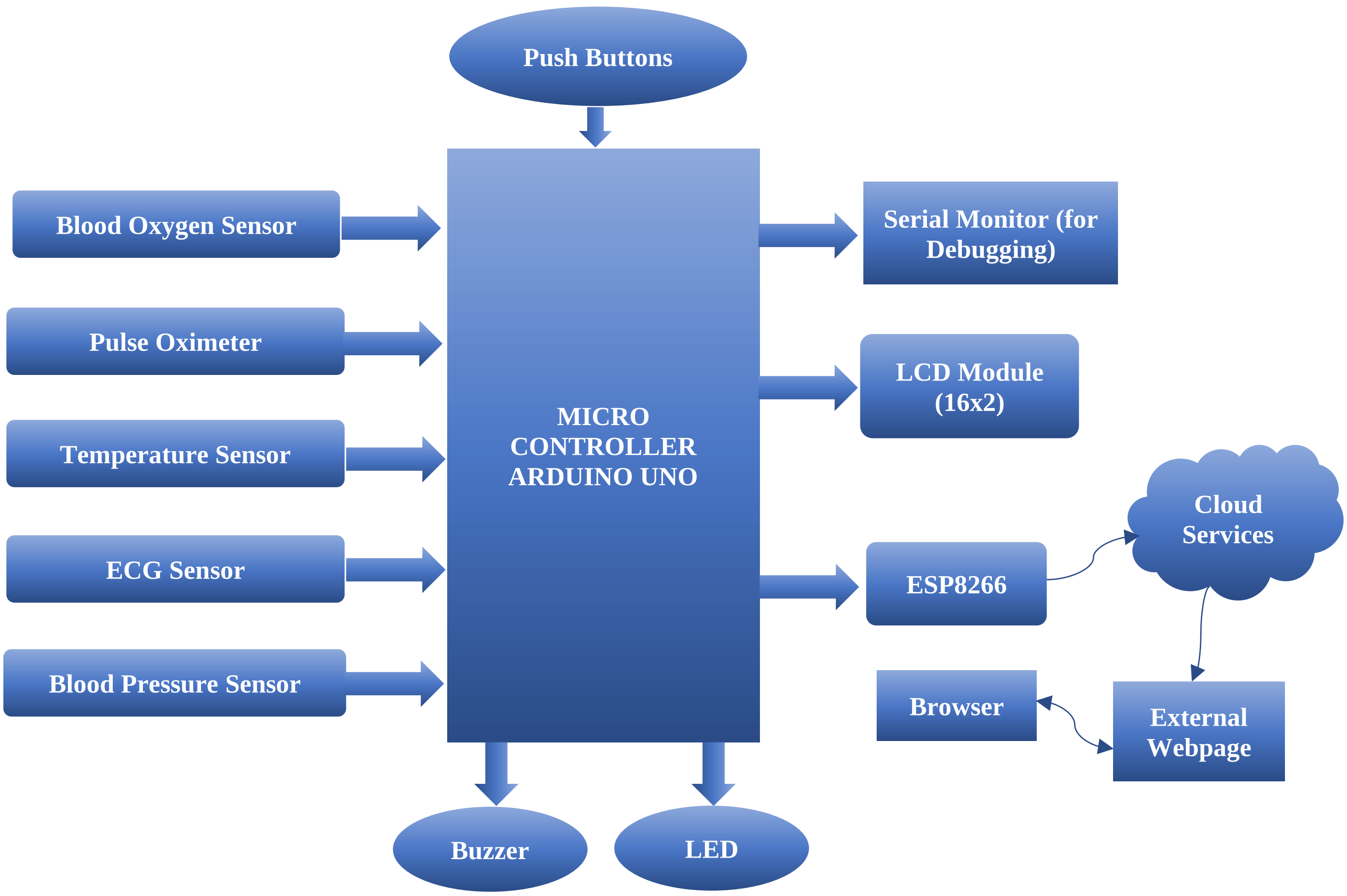

Fig. 3 Block Diagram of the Project

5.3. Circuit Diagram of the Project

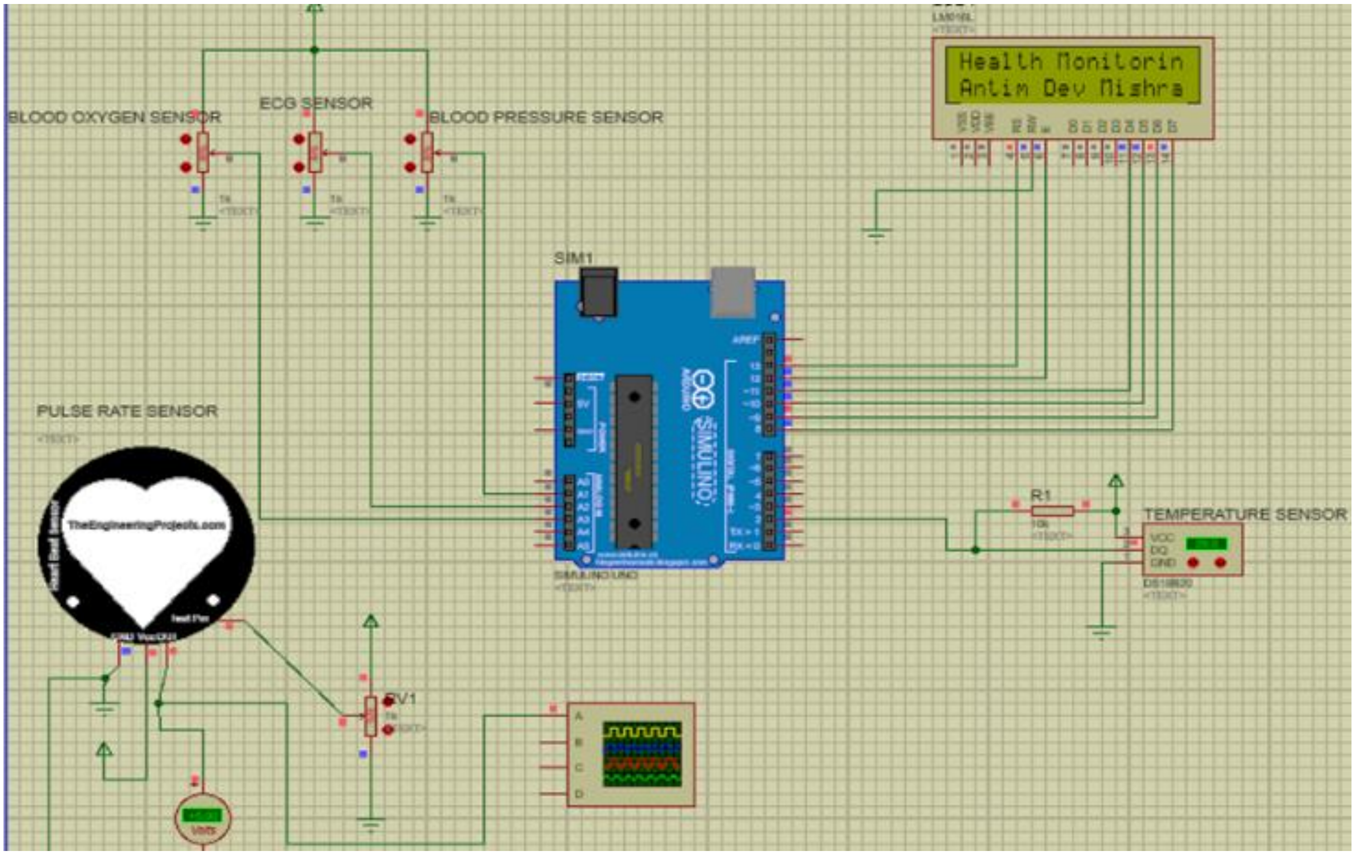

Fig. 4 Circuit Diagram of the project

6. Real Implementation

6.1. Node MCU (ESP8266)

The ESP8266 is a microcontroller device built with open-source software and hardware, an inexpensive system-on-a-chip development environment called Node MCU. Node MCU is essentially an (IoT) device, so it has been selected for all Internet of Things (IoT) projects. Expressive Systems design node MCU. This device contains a computer's essential components, including Wi-Fi, CPU, and RAM. It also has a neoteric operating system and SDK.

Fig. 5 Node MCU Module

However, the Node MCU is challenging to use and access as a single chip. To power or send signals to the "micro-computer" attached to the chip, it must solder its pins well with the appropriate analog voltage to implement code into a mid-level machine program that can be commanded to output by the hardware chip. ESP8266 is very user-friendly; it is used to connect to the Internet in this project. The module can work both to create a hotspot network and connect to Wi-Fi so that data can be exchanged easily, making the Internet of Things projects a breeze.

6.2. Arduino Uno

The Arduino Uno is a microcontroller based on the ATmega328P integrated circuit. It includes six PMW, six analogue input ports, and fourteen digital I/O pins. It receives programs through a USB connection. As a microcontroller unit, it contains all requirements to function. It has to be connected to a computer with a USB cable. Alternatively, it can be powered by a maximum 6-volt battery when the program is loaded. In the unlikely event that the chip is destroyed, the chip can be replaced for a few costs and start over. Arduino UNO is the best board to control electronic devices by coding as needed. UNO is very popular among users as the most used board in the Arduino family.

Fig. 6 Arduino Uno

Fig. 7 Pulse Sensor

6.3. Pulse Sensor

This Sensor combines a heart rate monitor and a pulse oximeter. It has an optical light sensor that can detect the absorbance of pulsatile blood through a photodiode after emitting light of two wavelengths – one red and one infrared from two LEDs. This specific LED can estimate the absorption of blood by the photodetector at that moment when placed on the fingertip. It has an I2C computerized interface to connect to the microcontroller. The MAX30100 chip inside this device operates at a voltage of 1.8V to a maximum of 3.3V, making it ideal for driving a lithium battery. They are always portable, wearable, and used in clinical checking gadgets.

MAX30100 Module Details:- The heart-rate sensing element resolution inside it can easily measure the little 5.6 mm x 2.12 mm x 2.8 mm 114-pin optical absorption inside the blood. LED current or ultra-low shutdown current (0.7µA) consumption from the pulse sensor is integrated closely to improve light-weight measurement, high sampling rate capability, and immediate sense output capability.

6.4. ECG Sensor

The ECG monitor module can be a low-cost electrocardiogram device. This does not capture the electrical signal of the heart. It charts the electrical activity inside the heart as a visual record and outputs analog readings. Since ECGs are complicated work, a single lead of the AD8232 acts as an operational amplifier to help provide a transparent signal to the pulse monitor.

The AD8232 is a compacted signal acquisition curb of applications for measuring electrocardiograms in an alternative potential. It is designed to extract, amplify and filter small potential biosignals under challenging conditions caused by cardiac motion conductor placement. The module has nine connections from the AD8232 IC, with only pins and wires soldered. 3.3V, GND, OUTPUT, LO, LO-, SDN These pins are connected to the required pins of a NodeMCU board.

Fig. 8 ECG Sensor

In addition, the pads attached to the right arm (RA), left arm (LA), and right leg (RL) need to be connected with glue to measure the signal on this ECG board.

*6.5. LCD Display (16*2)*

It is a 2-line liquid crystal screen capable of a primary 16-character display. Its writings are in white on a blue background. It is built using the very common HD44780 parallel interface chipset. A minimum of 6 digital I/O pins will be required to interface to this screen. The screen includes an LED backlight Small display of 16 characters x 2 lines that work in 4-bit and 8-bit modes.

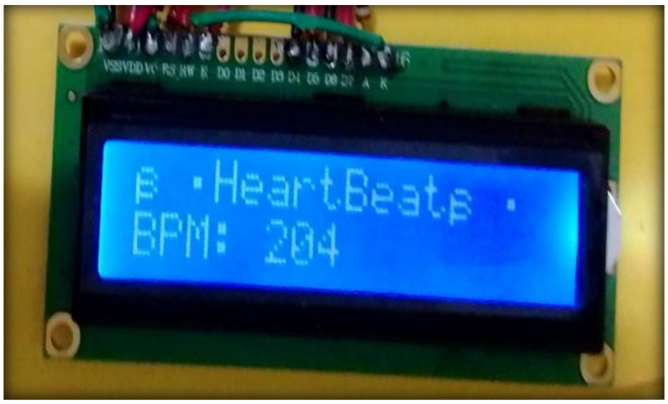

Fig. 9 LCD Display

6.6. Real Implementation of the Project

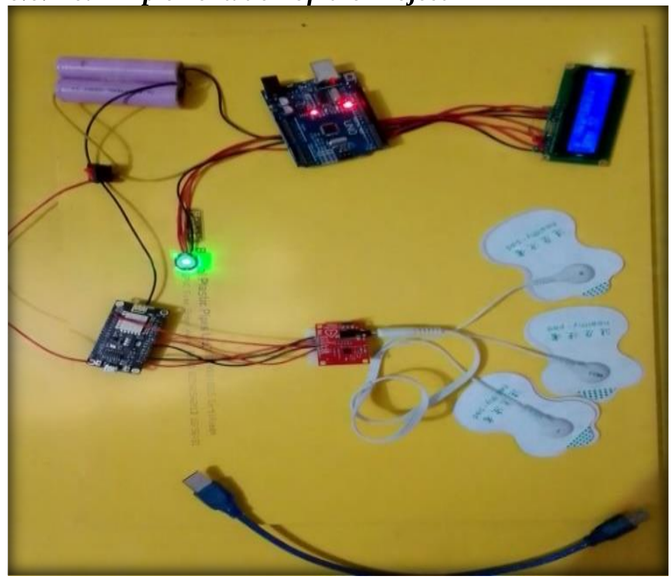

Fig. 10 Real Photo of the System

Features

- LCD controller/driver built-in.
- Blue backlight
- HD44780 equivalent
- 5x7 dot matrix character cursor

Fig. 11 API Server Dashboard

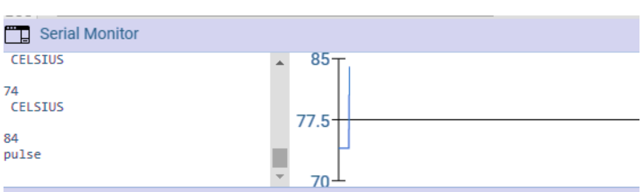

Fig. 12 Sensor Data in Serial Monitor

7. Result

Node MCU and Arduino Uno modules were used as Control Unite of the project. LM35 and pulse sensor are connected to the Arduino Uno, and the ECG sensor is joined in the Node MCU for the IoT-based medical device. These control systems gather, analyze, store, and transmit patient medical data to the cloud over a secure link.

Fig. 13 ECG Record on Webpage

This system has three sensors: pulse, temperature, and ECG. The user may pick and sort information by using push buttons. The physical device will instantly display patient data readings on the LCD and send the patient's health data to the cloud. The LCD module illuminates when the sensing mode is selected, displaying the patient's physical status as a numerical value on the digital display. The system displays the desired unit from the input and displays the output every three seconds.

Input sensors are connected to the analog input pin of the control unit and collect data. The Arduino Uno's central processing unit processes them and sends them to the output display and serial Monitor. Another control unit of the device is the NodeMCU which receives simultaneous commands from the patient throughout the transmission via Wi-Fi. It sets up the ESP8266 Wi-Fi module and sends signals to the web server using the "AT" command.

This command on the NodeMCU board displays the electric heart signals on the serial Monitor (for the debugging process) and sends information to the cloud server. A serial Monitor is a virtual dashboard with a USB connection between Computer and Control units (Arduino & NodeMCU).

The IoT platform's data exchange consists of four main components - ESP8266 (built-in Wi-Fi), a cloud server, and accessories, which are external web pages. Finally, it can be accessed through an online browser or mobile app. The ESP8266 and Arduino module work as standalone microcontrollers, but during this system, the ESP8266 is used only as a Wi-Fi device. It processes the data received from the ECG sensor and displays it on display.

8. Conclusion

The primary goal of the proposed system is to provide digitally enabled, cost-effective, and valuable services to patients by creating a cloud dashboard. It can collaborate more effectively with professionals and clinicians. The ultimate Model includes forms that permit a doctor to view a patient's health test results at any time. This project can send a complete health history of the patient's current and past conditions to the doctor in an emergency. The Internet of Things in this project is a set of technologies that enables computers and various devices to exchange data through multiple networking protocols. The IoT technology included in the project can be used for other services, including medical services, which is the objective of this research. An IoT network is used in healthcare systems to create and use interconnected devices for healthcare research, patient management, and immediate detection of conditions requiring physician intervention. So this modem technology will be the great dignity in the medical sector.

References

[1] Cooey Health, Re-Imagine Healthcare, 2021. [Online].Available: https://www.cooeyhealth.com

[2] Raja Jayaraman, Khaled Salah, and Nelson King, “Improving Opportunities in Healthcare Supply Chain Processes Via the Internet of Things and Blockchain Technology,” *International Journal of Healthcare Information Systems and Informatics*, vol. 14, no. 2, p. 17, 2019.[CrossRef] [Google Scholar] [Publisher Link]

[3] Temesghen Tekeste Habte et al., *IoT for Healthcare*, Ultra Low Power ECG Processing System for IoT Devices, Analog Circuits and Signal Processing, pp. 7-12, 2019. [CrossRef] [Publisher Link]
[4] Marinescu, D., Cloud Computing: Theory and Practice, 2012. [Google Scholar]
[5] Rajkumar Buyya et al., "Cloud Computing and Emerging IT Platforms: Vision, Hype, and Reality for Delivering Computing as the 5th Utility," *Future Generation Computer Systems*, vol. 25, no. 6, pp. 599-616, 2009. [CrossRef] [Google Scholar] [Publisher Link]
[6] Patan Rizwan, Rajasekhara Babu M, and Suresh K, "Design and Development of Low Investment Smart Hospital Using Internet of Things," *Biomedical Research*, vol. 28, no. 11, pp. 4979-85, 2017. [Publisher Link]
[7] K.R. Darshan, and K.R. Anandakumar, "A Comprehensive Review on Usage of Internet of Things (IoT) in Healthcare System," *2015 International Conference on Emerging Research in Electronics, Computer Science and Technology (ICERECT)*, pp. 132-136, 2015. [CrossRef] [Google Scholar] [Publisher Link]
[8] The Number of Connected Devices Globally From 2012 to 2020 According to the Internet of Things (IoT).
[9] Shahjalal et al., "Using Microcontroller Based Solar Power System for Reliable Power Supply," *Journal of Applied and Advanced Research*, vol. 7, pp. 18-24, 2022. [CrossRef] [Google Scholar] [Publisher Link]
[10] Md. Manirul Islam, "Development of a Noninvasive Continuous Blood Pressure Measurement and Monitoring System," *Proceedings of the International Conference on ICIEV*, pp. 1085-1090, 2012. [CrossRef] [Google Scholar] [Publisher Link]
[11] Xiaohui Liang et al., "Enabling Pervasive Healthcare Through Continuous Remote Health Monitoring," *IEEE Wireless Communications*, vol. 19, no. 6, pp. 10-18, 2012. [CrossRef] [Google Scholar] [Publisher Link]
[12] Richa et al., "An IoT Based Health Monitoring System Using Arduino Uno," *International Journal of Engineering Research & Technology*, vol. 10, no. 3, 2021. [CrossRef] [Google Scholar] [Publisher Link]
[13] Barera Sarwar et al., "Design and Application of Fuzzy Logic Based Fire Monitoring and Warning Systems for Smart Buildings," *Symmetry*, vol. 10, no. 11, 2018. [CrossRef] [Google Scholar] [Publisher Link]
[14] Kashif Hameed et al., "An Intelligent IoT Based Healthcare System Using Fuzzy Neural Networks," *Scientific Programming*, vol. 2020, pp. 1-15, 2020. [CrossRef] [Google Scholar] [Publisher Link]
[15] Er. Navjot Kaur, and Er. Yadwinder Kaur, "Object Classification Techniques Using Machine Learning Model," *International Journal of Computer Trends and Technology*, vol. 18, no. 4, pp. 170-174, 2014. [CrossRef] [Google Scholar] [Publisher Link]
[16] David Gil et al., "Internet of Things: A Review of Surveys Based on Context Aware Intelligent Services," *Sensors*, vol. 16, no. 7, 2016. [CrossRef] [Google Scholar] [Publisher Link]
[17] Nasrin Sadat Zarif et al., "A New Hybrid Method of Ipv6 Addressing in the Internet of Things," *2019 Smart Grid Conference (SGC)*, pp. 1-5, 2019. [CrossRef] [Google Scholar] [Publisher Link]
[18] Gonçalo Marques, Nuno Garcia, and Nuno Pombo, *A Survey on IOT: Architectures, Elements, Applications, QoS Platforms and Security Concepts*, Advances in Mobile Cloud Computing and Big Data in the 5G Era, vol. 22, pp. 115-130, 2017. [CrossRef] [Google Scholar] [Publisher Link]
[19] Gergely Alpár et al., "New Directions in IOT Privacy Using Attribute-Based Authentication," *Proceedings of the ACM International Conference on Computing Frontiers*, pp. 461-466, 2016. [CrossRef] [Google Scholar] [Publisher Link]
[20] Jorge Bernal Bernabe et al., "Holistic Privacy-Preserving Identity Management System for the Internet of Things," *Mobile Information Systems*, vol. 2017, pp. 1-20, 2017. [CrossRef] [Google Scholar] [Publisher Link]

Appendix

Pulse Sensing Code

```
#include <PulseSensor Playground.h>
#include <LiquidCrystal.h>
const int RS = D6, EN = D5, d4 = D1, d5 = D2
LiquidCrystal lcd(RS, EN, d4, d5, d6, d7);

const int Pulse Wire = A0;
const int LED_3 = D0;
int Threshold 550;
byte heart1 [8] = {B11111, B11111, B11111,
B00011, B00001}
byte heart2[8] = {B00011, B00001, B00000,
B00000, B00000};
byte heart3[8] = {B00011, B00111, B01111
B11111, B01111};
byte heart4[8] = {B11000, B11100, B11110,
B11111, B11111};
byte heart5[8] = {B00011, B00111, B01111,
B11111, B11111};
byte heart6[8] = {B11000, B11100, B11110
B11111, B11110};
byte heart7[8] = {B11000, B10000, B00000,
B00000, B00000}
byte heart8[8] = {B11111, B11111, B11111,
B11000, B10000};
int Instructions_view = 500;
PulseSensor Playground pulseSensor;
void setup() {
  Serial.begin(9600);
  lcd.begin(16, 2);
  lcd.createChar(1, heart1);
  lcd.createChar(2, heart2);
  lcd.createChar(3, heart3);
  lcd.createChar(4, heart4);
```

```
    lcd.createChar(5, heart5);
    lcd.createChar(6, heart6);
    lcd.createChar(7, heart7);

   lcd.createChar(8, heart8);
  lcd.setCursor(0,0);
  lcd.print(" HeartBeat Rate ");
  lcd.setCursor(0,1);
  lcd.print(" Monitoring ");
  pulseSensor.analogInput(Pulse Wire);
  pulse Sensor.blink OnPulse(LED_3);
  pulseSensor.setThreshold(Threshold);
  if (pulseSensor.begin()) {
  Serial.println("We created a pulseSensor Object !");
  }
    delay(2000);
    lcd.clear():
}
 void loop() {
   int myBPM = pulse Sensor.getBeatsPerMinute();

   if (pulse Sensor.sawStartOfBeat()) {
        Serial.println("❤ A HeartBeat Happened!");
        Serial.print("BPM: ");
        Serial.println(myBPM);
        lcd.setCursor(1,1);
        lcd.write(byte(1));
        lcd.setCursor(0,1);
        lcd.write(byte(2));
        lcd.setCursor(0,0);
        lcd.write(byte(3));
        lcd.setCursor(1,0);
        lcd.write(byte(4));
        lcd.setCursor(2,0);
        lcd.write(byte(5));
        lcd.setCursor(3,0);
        lcd.write(byte(6));
        lcd.setCursor(3,1);
        lcd.write(byte(7));
        lcd.setCursor(2,1);
         lcd.write(byte(8));
         lcd.setCursor(5,0);
         lcd.print("Heart Rate");
         lcd.setCursor(5,1); lcd.print(":");
         lcd.print(myBPM); lcd.print(" ");
         lcd.print("BPM ");
         Instructions_view = 0;
         }
          delay(20);
         }
```

ECG Monitoring Code:

```
#include <ESP8266WiFi.h>
#include <PubSubClient.h>
#define WIFISSID "Nayem CSE"
#define PASSWORD "nayem2021"
#define TOKEN "BBFF-YKXITsj1YPeTMxw7mq
#define MQTT_CLIENT_NAME "myecgsensor"
#define VARIABLE_LABEL "myecg"
#define DEVICE_LABEL "esp8266"
#define SENSOR A0
 char mqttBroker[] = "industrial.api.ubidots.com";
 char payload[100]:
 char topic[150];
 char str_sensor[10];
 WiFiClient ubidots;
 PubSubClient client(ubidots);

 void callback(char* topic, byte* payload) {
   char p[length + 1];
   memcpy(p. payload, length);
   p[length] = NULL;
   Serial.write(payload, length);
   Serial.println(topic);
}
   delay(2000);
  }
 }
}
void setup() {
   Serial.begin(115200);
   WiFi.begin(WIFISSID, PASSWORD);
    // Assign the pin as INPUT
   pinMode(SENSOR, INPUT);
   Serial.println(); Serial.print("Waiting for WiFi...");
   while (WiFi.status() != WL_CONNECTED) {
    Serial.print(".");
    delay(500);
    }
   Serial.println("");
   Serial.println("WiFi Connected");
   Serial.println("IP address: ");
   Serial.println(WiFi.localIP());
   client.setServer(mqttBroker, 1883);
   client.setCallback(callback);
}
 void loop() {
   if (!client.connected()) {
    reconnect():
    }
   sprintf(topic, "%s%s", "/v1.6/devices/", DEVICE.);
    sprintf(payload "%s", ""); // Cleans the payload
   sprintf(payload, "{\"%s\":", VARIABLE_LABEI
   float myecg= analogRead(SENSOR);
   dtostrf(myecg, 4, 2, str_sensor);
   sprintf(payload, "%s {\"value": %s}}", payload);
   Serial.println("Publishing data to Ubidots Cloud"),
   client.publish(topic, payload);
   client.loop();
   client.loop();
   delay(10);
}
```