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Wireless Patient Health Monitoring System using Internet of Things and Mobile device

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***Abstract*— In this current decade, the healthcare monitoring systems are gaining more importance among researchers. The major objective is to develop a robust patient monitoring system so that the health experts can track the patients' health status, admitted in the hospitals or patients discharged but needs follow up of the doctors. This research work presents a wireless healthcare monitoring system using mobile device which delivers online data in real time about a patients' physiological status. This proposed project is developed to monitor and quantify patients' crucial physiological data precisely. Also, the proposed system transmits a message to alarm the serious health condition of the patient via text or email messages. Further these provide necessary medical guidelines to the healthcare professionals. The important constituents of the proposed system are data acquisition unit, sensors, Arduino (microcontroller), and software. The proposed system monitors, displays, and stores the patient's ECG data, heart beat rate, muscles, temperature, blood glucose level and blood pressure. The results of the developed system illustrate that the physiological data of the patients are measured with high accuracy.**

Keywords*— *Wireless; Sensors; Arduino; Health Monitoring System; Online; Mobile device, Internet of Things.

I. INTRODUCTION

In recent decades, IoT has grabbed the most of automation and control areas of modern industries. Biomedical applications are also automated to deliver advanced healthcare. The IoT technology has provide the hi-tech facilities for the personal health care along with in hospitals. But a smart health care system increase efficiency consuming more power and cost. Doctors have a very crucial role in health monitoring systems, but the check-up process is tedious and time consuming. As a patient need to first register and take the appointment, wait for his check up in hospital queues, and after check-ups, reports are generated. Because of this long procedure, employed people be likely to cancel or delay check-ups.

This project proposes a wireless system that is capable of health monitoring of multiple patients in real-time. In health care centres patient's data such as heart rate is essentially to be monitored constantly. The proposed system observes the heart rate and other crucial data of the physiological condition of the patient, viz., heart rate is measured through a Photoplethysmography. A transmitter module is connected which performs continuous transmission of the coded serial data by means of the Zigbee unit.

A receiving system is positioned in the cabin of the doctor, that performs the reception and decoding of the data which is displayed continuously on a User Interface observable on PC/Laptop. Thus, health experts can notice and monitor many patients simultaneously. System also constantly observes the data of the patient(s) and in critical condition of a patient, the alarming system coupled to the system provides an audio-visual alarm signal that the patient of a specific room wants immediate care. If, the doctor is not available in his cabin, the GSM modem associated to the system also transmits a message to all the doctors of that unit providing the room number of the patient who requires intensive attention. This is especially for observing the senior citizen patients and notifying doctors and care takers. This system exploits heartbeat and temperature sensors for tracing the physiological condition of the patients. Together the sensors are coupled to the Arduino-Uno.

To monitor the patient's condition, the output of the microcontroller is connected to a LCD display unit and Wi-Fi is used to transmit the data to the wireless sensing node (web-server). If any unexpected fluctuations in heart-rate or body temperature of patient is observed then an alert message is transmitted about the patient's health condition via Internet of Things (IoT). This proposed system furthermore displays temperature and heartbeat of the patient and also traced real-time data using timestamps via Internet. Thus, health tracking system for patient based on IoT utilizes the internet to efficiently observe patient's condition and aids the user to monitor their relatives and saves their lives.

II. LITERATURE SURVEY

Tamilselvi V. et.al [1] proposed "IoT based health monitoring system", in Sixth International Conference on Advanced Computing and Communication Systems (ICACCS). IEEE; 2020. They have proposed health monitoring system can track a patient's physiological information viz., body temperature, eye movement oxygen saturation percentage, and heart rate in an IoT network. The system uses sensors to acquire temperature, eye blink sensors, SpO2 and heart rate data, which is further processed by Arduino-UNO. The proposed system developed, has no explicit performance parameters are defined for any patient.

Acharya A. D. and Patil S. N., [2] proposed "IoT based health care monitoring kit", in Fourth International Conference on Computing Methodologies and Communication (ICCMC). IEEE; 2020. They presented a kit for healthcare monitoring using IoT. The proposed system tracked some elementary factors like ECG, heartbeat, respiration, and body temperature. The main hardware modules used here are ECG sensor, pulse sensor, temperature sensor, BP sensor to aquire the related datas later sent for processing using Raspberry-pi, and further transmitted on IoT-network. The main disadvantage of the scheme is that, they have not developed any interfaces for data visualization.

Trivedi S. and Cheeran A. N., [3\ developed "Android based health parameter monitoring". in International conference on intelligent computing and control systems (ICICCS). IEEE; 2017. They proposed Arduino-based, cell phone controlled health parameter observation system. The data acquired by sensors are analog signals, which are fed to the Arduino Uno board. An analog to digital converter is integrated which is used to convert analog signals into digital data. Using Bluetooth technology, the physical quantities are sent to a device which is specially developed. The drawback associated with this system is, this Bluetooth device used a unit which could not cover a widespread area.

Kumar SP, Samson VRR, Sai UB, Rao PLSDM, Eswar KK [4] proposed "Smart health monitoring system of patient through IoT" in (I-SMAC). IEEE; 2017. They presented an adaptive IoT safety tracking device. A DS18B20 sensor was utilized for measurement of body temperature in the control unit and a pulse sensor is utilized for the pulse measurement. The data were fed from Arduino over the Wi-Fi unit andEthernet shield into the cloud on the transport layer. The framework layer gathered together details of the server. The Arduino-Uno was utilized and therefore, several sensors couldnot be handled suitably.

Desai M. R., and Toravi S., [5] proposed "A smart sensor interface for smart homes and heart beat monitoring using WSN in IoT environment", in International conference on current trends in computer, electrical, electronics and communication (CTCEEC). IEEE; 2017.

They implemented a wireless sensor network (WSN) to monitor heartbeat and smart homes. They employed the FPGA architecture in parallel with Spartan3 for processing of data. The outcomes are displayed on a LCD, and outputs of all the sensors are fed to a microcontroller. But, the drawback of the system is, all the components used are not combined as one single framework.

C. Senthamilarasi et. al.,[6] proposed "Patient Health Monitoring System using Internet of Things" in IJPAM, 2018. They have developed a technology oriented healthcare monitoring system. Their first goal was to implement a consistent IoT-based patient monitoring system for healthcare experts to track their hospitalized patients or admitted using an integrated IoT-based healthcare system to assure best possible care for the patients. The system tracks, and displays output and records the EEG, heart rate and temperature data of patients and is sent it to the doctor's phone that contains the developed device. Thus, the patient tracking system using an Internet of Things network efficiently observers the status of patient and avoids his/her life threat.

Ahmed Abdulkadir Ibrahim and Wang Zhuopeng [7] proposed "IoT Patient Health Monitoring System", in IJERA, 2018. The system tracks and stores various medical parameters of patients outside the hospitals. All physiological data of patient will be deposited in the cloud, it lets doctors to track the healthstatus of patients. The doctor can constantly track the patient's health status on his Android phones. The power consumption of the Wi-Fi module (ESP8266) is designed to drop to the maximum possible amount. The proposed system thus delivers reduced power consumption with less complications and is very portable device for tracking health condition of patients.

C. Premalatha et. al.,[8] proposed "Human Health Monitoring System" in IRJET, 2019. They designed the system utilizing the Internet of Things (IoT) and cloud computation unit. This feature allowed for providing remote and efficient services. In a critical condition, an SMS is sent to a doctor or caretakers of the patient. This paper represents a model of a wireless health checking scheme which is able of transmitting SMS associated to the patient's health condition.

Prashant Patil et. al.,[9] designed "Patient Health Monitoring System using Internet of Things" in IRJET, 2017. This developed project allows a patient to wear hardware integrated with sensors and android phone app. The patient's blood temperature and heart rate are acquired by various sensors, further this data is transferred to the phone. The system has a cloud database where all the data regarding the health status of the patients are deposited and the doctors will advise the treatment and medicines referring to this information stored in the cloud. The Android phone will comprise an application that can identify the threat according to the received data, and if any anomalies related to the threat are detected, an alert message will be sent to the doctor, relatives of the patient.

Themessage contains the information regarding the health condition and geographical location of the patient (via GPS) to provide urgent medical advice and treatment.

Surekha N. et. al.,[10] designed "Patient Tracking System using IoT", IJIRAE, 2018. It becomes essential to go to hospitals frequently for doctor's consultation, which involves a financial and time consuming process. . To avoid this situation, the authors have presented a proposal that will describe the health condition of the patient such as heart rate, temperature, blood pressure and ECG and the message is sent to the doctors and care takers using GSM.

III. PROBLEM STATEMENT

In hospitals, where a regular tracking of patient's health condition is essential, it is generally performed by a doctor or other paramedical staff by regularly noting down various crucial parameters, such as heartbeat, body temperature and blood pressure. This work becomes tiresome after some time and human errors may occur. Even during the period of pandemic, it is very tough for doctors to physically check the patients. Hence, it is essential to develop rapid, appropriate and competent technology that is proficient in aiding doctors and hospital staff. A device capable to track the real time status of a patient admitted in the hospital is to be developed.

Such a device should be capable of communicating with the corresponding nurse, doctor, or any other care takers, the health condition of the respective patients under observation. A device should be capable to acquire and investigate the data which is being communicated to doctors, hospital staff regarding the status of the patient for the observation period of time. It is necessary to develop a device which is can send an emergency notifications, or alerts so as to deliver the immediate health condition of the patient to its respective doctor, nurse or caretaker etc.

IV. PROPOSED METHODOLOGY

A. FLOW CHART

As illustrated in the block diagram below, the system comprises of development of the Wireless Patient Healthcare Monitoring System using IoT.

The flowchart as shown in fig. 1, shows the program-stages for developing the system. The program begins by accepting the signal-outputs from the sensors which are connected to the body of the patient via wires. The data collected from sensors is then transmitted to the software development module. The program investigates and provides the data for the display unit about the heart rate, body temperature and ECG.

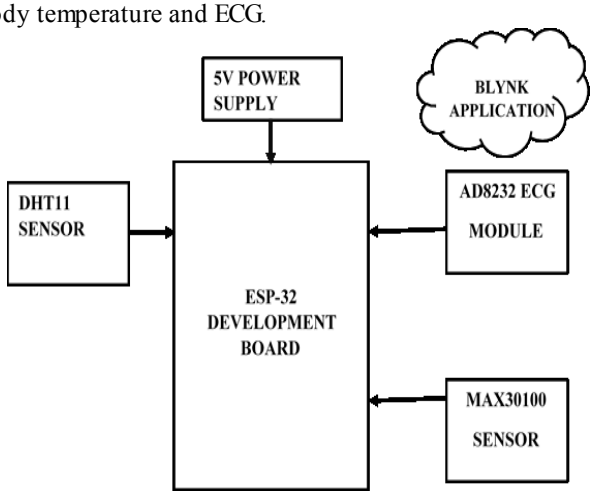

Fig.1 Block diagram of proposed system

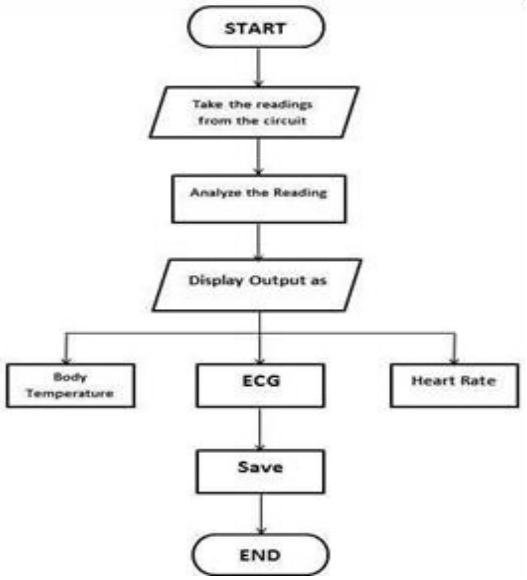

Fig.2. Flow chart of proposed system

Finally, the data are stored and also referred to produce well-organized information regarding patients' status by the system in real time.

B. BLOCK DIAGRAM

The figure 3 shows the circuit connections of the proposed methodology which is mentioned earlier.

V. HARDWARE and SOFTWARE

A. HARDWARE COMPONENTS

The hardware modules that are required to develop the proposed system, as outlined by the problem statement, proposed methodology and its working process, are listed in table 1.

Table 1 List of required hardware

Sl.No	Name	Specification	Quantity
1.	NodeMCU	ESP32	1
2.	Pulse-Oximeter	MAX30100	1
3.	Temperature Sensor	DHT11	1
4.	ECG Sensor	AD8232	1

The figure 2 presents block diagram of proposed software model. The sensors continuously track and provide the information about patient's health status to the doctors over the Wi-Fi Module using Blynk server. The doctor can analyse this retrieved data anytime and anywhere from his mobile phone. This aids the doctors to emphasis more on the patient's status. This enhances quality of health checking process and can store all the particulars concerning the patient's health. The health tracking sensors are utilised to acquire health associated data i.e. for data capturing. This acquired data can be communicated by a controller over the internet wirelessly. The processing of this acquired data has to be performed at the server. All data acquired is combined at server end (Blynk Server), to present health associated data in meaningful arrangement.

C. CIRCUIT CONNECTIONS

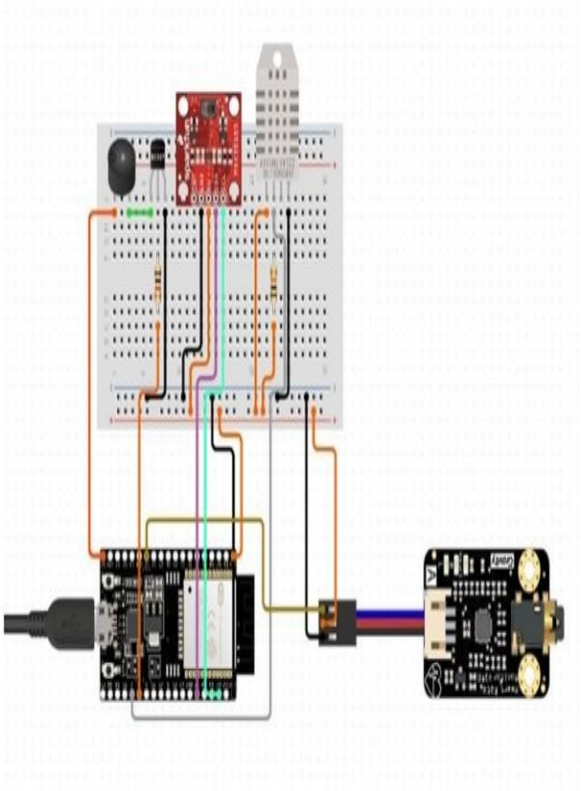

Fig 3: Circuit Connections

1. ESP-32 DEVELOPMENT BOARD

NodeMCU is a firmware available on open-source for which prototyping board designs are also available on open source. The name "NodeMCU" consists of "node" and "MCU" (micro-controller unit). It is referred as firmware than development unit. The firmware and prototyping board designs are available on open source platform. The figure 4 presents ESP-32 Dev Kit (NodeMCU)

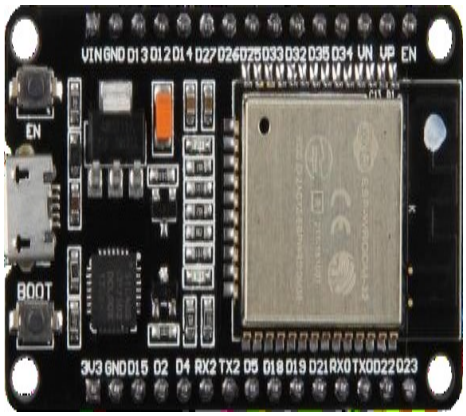

Fig 4: ESP-32 DEVKIT V1

Fig 5: Pulse Oximeter MAX 30100

2. MAX 30100 Pulse Oximeter Sensor

The pulse oximetry subsystem in MAX30100 board is as shown in figure 5. It contains of an unit referred as ambient light cancellation (ALC), ADC - sigma delta of 16-bit, and registered filter (discrete time). It contains an ultra-low-power process that is suitable for battery operated systems.

MAX30100 sensor functions on a power supply from 1.8 to 3.3V. It is suitable used in wearable devices, medical tracking devices and fitness devices etc.

The MAX30100 runs on power supply ranging from 1.8V to 3.3V power supplies and could be powered-down via software by only using negligible standby current, which allows the power supply to be connected at all times.

3. Temperature Sensor DHT11

The DHT11 is a usually used humidity and temperature sensor. The sensor has an integrated element, NTC to quantify temperature which is connected to a microcontroller of 8-bit to produce the values of humidity and temperature as serial data.

Pin Description:

- DHT11 is a 4-pin sensor. The pins are meant to provide VCC, DATA, GND and one pin is not in use,as shown in figure 6.

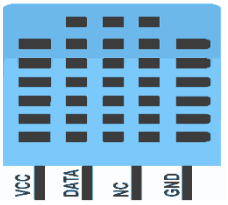

Fig. 6: DTH11

Table 2: Pin diagram of DHT11

Pin No.	Pin Name	Pin Description
1	VCC	Power supply 3.3 to 5.5 Volt DC
2	DATA	Digital output pin
3	NC	Not in use
4	GND	Ground

4. ECG Sensor Module (AD8232)

ECG registers the electrical signal produced by depolarizations of heart muscle (a negative change in the electric charge), which is sent as pulsating electrical waves towards patient's skin. Even though the quantity of electricity is very minor (in microvolts, or uV), it is reliably sensed up byelectrodes of ECG connected to the skin.

The complete ECG- unit includes four electrodes that are attached on to the chest part of the patient or at the four extremes (the right arm, left arm, right leg, and left leg). Therealso exist variants of this arrangement so as to permit additional flexible and less invasive readings. For example, it is likely to connect electrodes only to the legs and forearms. The ECG electrodes are usually wet-sensors, hence a conductive gel is required to enhance connectivity between electrodes and skin. Heart Rate (HR) reflects the frequency of a whole heartbeat from its production to the start of the subsequent beat within a precise time gap. It is usually expressed as bpm (beats per minute). HR can also be derived via ECG and EEG sensors. An increased HR usually indicates amplified is stimulation.

Fig 7: ECG Sensor Module (AD 8232)

The AD 8232 is popularly used heart rate monitor, as shown in figure 7. It has nine connectivity pins from the IC that can be soldered using wires, or other connectors to SDN, LO+, LO-, OUTPUT, 3.3V and GND. These are necessary pins for functioning this monitor with an Arduino or other development board. Also pins marked as RA (Right Arm), LA (Left Arm), and RL (Right Leg) available on this board usedto connect to a patient's body parts.

B. SOFTWARE TOOLS:

1. BLYNK SOFTWARE

Blynk is software module developed for the Internet of Things. It is capable to regulate hardware from a remote distance. Blynk is capable of displaying sensor data, it can collect data, and can also help to visualize it. It lets the user to derive remarkable interfaces that can be connected to a developed tasks using several advanced widgets which are available. Blynk platform contains three main parts to develop an application:

- Blynk App - permits the user to design adequate interfaces for developing the applications exploiting several advanced widgets.
- Blynk Server – regulates the transaction between the hardware and smartphone. User can utilize the Blynk Cloud or executed on a locally available private - Blynk server . It is a software available on open- source, can adequately control several devices which can also be integrated with a Raspberry-Pi.
- Blynk Libraries – are integrated with all the prevalent hardware-platforms - support transaction between the servers and process incoming and outgoing commands.Now visualize: each time a Button is pressed in the Blynk app, a message is sent to the Blynk-Cloud, where it

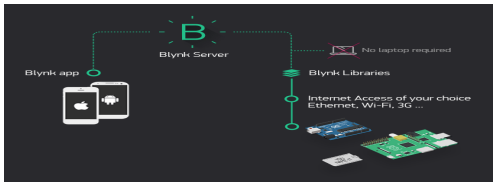

Fig 8: How blynk application works

automatically connects to the hardware. It operates in the same manner even in the opposite direction and whole processoccurs in a blynk of an eye, as outlined in figure 8.

2. ARDUINO IDE

The Arduino Integrated Development Environment (IDE) is an application in cross-platform for platforms viz., MacOS, Linux Windows that is implemented in C and C++. Arduino is a hardware platform available open-source, which provides user friendly software and hardware operations. Arduino units are capable to sense inputs like – light energy falling on a sensor, a finger pressing on a button, or a message on Twitter - and convert it into an action like - making a motor on/off, turning- on an LED, some information publishing online. User can program the board by transmitting a set of commands to the on-board microcontroller.

In this project we are connecting the sensors on to the patients' body. These sensors continuously track and direct the data to the doctors' smartphone via the Wi-Fi Module using Blynk server.

Local Server Using ESP32:
ESP32 Standalone Web Server is accessible by smartphone, computers, laptops and tablets which are connected to the same Wi-Fi network as ESP32. As an illustration of the web server, we developed a simple web page that can be retrieved by clients and track the patients' health wirelessly.

VI. RESULTS AND DISCUSSION

The Wireless Patient Health Monitoring and Alerting System is the contemporary solution for the implementation of scientific device that aids doctors and nurses to check, track, and investigate from the incoming of any health issues.

Fig 9: SPO2, Heart Rate, Temperature and ECG display.

As the primary condition that one should check is the immediate stats of oneself. Like heartbeat rate, blood pressure, ECG, and body temperature as one could estimate one's body's condition from these simple stats of one's body. The display of various parameters of a patient viz., SPO2 level, Heart rate, Temperature and ECG are as shown in figure 9.

This will help the patient, doctor, nurse, or any other interested party to know about the patient's history of the condition or health issues.

With the help of which the doctor or nurse can decide the best treatment for his/her patient. And can plan the upcoming treatments with utmost precision. As all the data which was collected from the patient can be viewed or made use whenever required.

VII. CONCLUSION

The proposed system had been developed efficiently with acceptable outputs. All the modules shown their performance almost accurately. The proposed arrangement delivered consistent and satisfactory results. By using this wireless system, it will be much convenient to modify a traditional patient monitoring arrangement into a wireless smart patient monitoring system. This arrangement will be very supportive for hospital application as the output readings can becomprehended from the hospital central computer system through Bluetooth network. As well as nurses can utilise the readings for their regular observation purpose.

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