Virtual Heart Rate Monitoring system using Node-MCU and Thing-Speak Cloud

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Abstract— In the path of using latest and advanced technology for the welfare of society, it is very necessary to use the technology in the right and efficient way. Taking care of the present pandemic condition of COVID-19, this wireless virtual Heart Rate Monitoring system will play a vital role in real time monitoring of Heart patients. This is about the monitoring pulse rate without being in touch with the patient with the help of Internet of Things (IoT) and sensors. The biggest advantage of this system is that it gives real time as well as previous history of patient Pulse Rate for better monitoring and analyzing of his/her health status. This system ensures the optimized and instant updates of health status of patient and reduces the death chances due to lack of instant action in case of Heart attacks. In this research paper, we have focused on getting real time update and notify to concern people until any action taken through various communications protocol that comes under the term Internet of Things (IoT). We are having two way to notify that is first via app notification and second via email notification. This is all about the advancement in smart pulse rate monitoring system by linking it with Internet of Thing (IoT) with instant notification which makes this system more reliable and optimized. This type of smart and user friendly system helps to monitor with ease and also easy to understand.

Keywords: Heart Rate monitoring system, Internet of Thing (IoT), Pulse Rate, Communications protocol

I. INTRODUCTION

There are many diseases such as tuberculosis, pneumonia etc. which demands need for monitoring of pulse rate of patient as these diseases are contagious and can transmit through medium of air, object surface in vicinity of patient. It is important to contain pathogens causing disease to limited area or just patient and its associated belongings to prevent spread. Since pathogens are not visible to naked eye, professional health care workers also have same probability as of patient's family member of being vulnerable to pathogen exposure. It is been observed in many cases that Personal protective equipment (PPE) also fails to prevent exposure to pathogens. Therefor social distancing or virtual monitoring will help to monitor patient's vital parameters continuously. One of most important parameter i.e. pulse rate depicts working of heart and healthy pumping of blood along with amount of oxygenated blood. Oxygenated blood amount is critical parameter and is very important for patient undergoing diagnosis or recovery. Monitoring of such critical parameter without getting exposed to disease causing pathogen is a challenge for health care professionals as it is meant for working of respiratory and nervous system of patient body for fighting biologically with pathogen interfering with health. This proposed method not only offers user-based accessibility for specialists [1]. Today, all time-consuming occupations have also been replaced by wireless technology; patients may be independent of instrumentation and beds [2]. How-ever to perform monitoring and tracking tasks to the physiological parameters for the patient, different portable devices are made. Any of these types of devices are heart rate monitors, pulse ox-meters, and blood pressure [6]. In addition, through wires, the patient may be connected to these instruments and become bed-bound in sequential movement, as well as discrete continuous movement may occur in the monitoring devices through disconnection and later reconnection [8]. In order to bring about exciting opportunities in the medical markets, modern applications have been presented by wireless technologies [9].

The work performed in the research paper is to develop a device application for the patient to calculate heart pulse and view the heart pulse in real time through a smartphone over the network. The principle is to reduce the mortality rate and take urgent action if the pulse rate reaches the threshold or below the threshold limit. Because periodic physical care of the patient is not needed, the cost of treatment will also be reduced. The proposed system is using a Pulse sensor, Node-MCU, Ethernet, Thing-speak free cloud and Smartphone.

II. REVIEW OF LITERATURE

[1] NabeelSalih Ali et.al (2018) [1] proposed a Real-time Heart Pulse Monitoring Technique Using Wireless Sensor Network and Mobile Application. This suggested a real-time heart pulse monitoring system for patients through an electronic circuit design to measure heart pulse (HP) and to view heart pulse measurements in authentic situations using mobile and screen over the internet. Using sensor systems to analyze heart pulse in HP sensing application perspective by carrying the fingerprint to the sensor through used Arduino microcontroller with Ethernet shield to link the heart pulse circuit to the server and send results to and receive them everywhere on the web server. The proposed framework has not only helped the user with usability (user-friendly) by the specialist. It also provided accuracy and speed of performance, the highest consumer availability on a continuing process, and at a cost of coffee.

[2] Ibrahim et.al (2017) [2] proposed a Non-contact Heart Rate Monitoring Analysis from Various Distances with different Face Regions. Probable facial landmarks are calculated in this paper by using cascaded regression mechanisms. Next in a face position where non-rigid movement is marginal, the region of interest (ROI) was built from the landmarks. The temporal photo plethysmo graph (PPG) signal is determined from the ROI based on an average intensity of green pixels and the independent component analysis (ICA) filter separates the environmental lighting. Subsequently, the PPG signal can be further processed to eliminate frequencies outside the range of consideration prior to HR estimation using a

sequence of temporal filters. To conclude, by using lower portion of the face field, the HR can be identified up to 5 meters with 94 percent accuracy.

[3] Tadi MJ et.al (2016) [3] presented a heart rate monitoring using a Hilbert transform in seismocardiograms.This paper introduced the Hilbert adaptive beat recognition technique in three distinct positions i.e. supine, left and right recumbent, for the detection of pulse timings and inter-beat time intervals in SCG from healthy human volunteers. The electrocardiogram (ECG) method is independent, as no ECG fiducial points were needed to predict the beat-to-beat gaps. The algorithm's output was checked against standard ECG parameters.Supine (95.8 percent, 96.0 percent and 0.6 percent), left (99.3 percent, 98.8 percent and 0.001 percent) and right (99.53 percent, 99.3 percent and 0.01 percent) were the average true positive rate, positive prediction value and identification error rate for the various positions, respectively. High correlation existence and agreement with SCG and ECG inter-beat intervals ($r > 0.99$) was found for all positions, demonstrating the capacity of the SCG heart monitoring mechanism at multiple positions.In addition, it showed the usefulness of the proposed Mobile SCG process. In conclusion, the suggested algorithm was used for continual uncluttered real-time cardiac tracking, mobile cardiography , and for health and well-being applications in wearable devices.

[4] Rajput DS and Gour R (2016) [4] presented an IoT framework for healthcare monitoring systems. E-Health Monitoring(EHM) was presented in this chapter and an architectural structure was introduced to explain the entire life cycle of tracking and highlight critical service components. It has served as a basic principle for rigorous, reliable and safe monitoring of health. The key goals of this paper were to develop an IOT-based architecture for health-related problems such as diabetics, heart monitoring system, measurement of pulse rate, daily activity, kidney functioning. The obtained information through sensors is stored on the cloud and shared with the others. The information obtained via sensors is processed and accessed through a smartphone.

[5] Kakria P et.al (2015) [5] developed a real-time health monitoring system for remote cardiac patients using smartphone and wearable sensors. Throughout this paper, cost consideration, ease of use, accuracy, and data protection, a real-time heart monitoring system is designed. For two-way communication, the device is conceptualized to provide an interface between the doctor and the patients. The aim of this research was to make it easier for remote cardiac patients to get the new healthcare services that would not otherwise be feasible because of the low doctor-to-patient ratio. The built monitoring system is then tested using wearable sensors for 40 people (aged between 18 and 66 years) while holding an Android device (i.e., smartphone under supervision of the experts). Due to the high speed, the performance review demonstrated that the developed system is efficient and effective. Analyses have shown that the system proposed is simple and efficient and guarantees low-cost data protection. In addition, under critical circumstances, the established system was designed to produce warning signals for the doctor and patient.

[6] Minaie A et.al (2013) [6] studied the application of wireless sensor networks (WSNs) in healthcare system and issued some upgradation for shortcomings in existing system. This study found that there are certain limitations which need to be resolved in the current implementation of WMSNs in the healthcare system. There were three main categories for the implementation of Wireless Sensor Networks in healthcare systems: patient tracking in clinical environments, home and elderly care center tracking for chronic and elderly patients, and long-term database collection of clinical data. The WSN research group has done a brilliant job of solving a few of the existing weaknesses for healthcare-related applications; although in addition to further enhancements to wireless communication, changes are still needed regarding security and privacy problems.

[7] Aminian M and Naji HR (2013) [7] developed a Hospital healthcare monitoring system that has the capability to monitor physiological parameters from multiple patient bodies. A supervisor node is connected to the patient's body in the proposed system to gather all the signals from the wireless sensors and transfer them to the base station. A wireless body sensor network (WBSN) is created by the attached sensors on the body of the patient and they can sense heart rate, blood pressure, and so on. This sensor can detect suspicious conditions, give the patient a warning, and send the doctor an SMS/E-mail. The suggested system is comprised with several wireless relay nodes that are responsible for conveying and transmitting to the base station the data sent by the coordinator node. In contrast to previous systems, the key benefit of this system is to minimize energy usage to prolong the life of the network, speed up and expand connectivity range to increase the freedom to improve the quality of life of patients. They implemented the system in the multi-patient hospital healthcare infrastructure and contrasted it with other existing multi-hop relay node-based networks in terms of range, power consumption and speed.

S. No.	Author	Software/ Equipment used	Application	Observation	System configuration
1.	NabeelSalih Ali et.al (2018)	LBF filter, Arduino UNO board, LM368 amplifier, (IR Emitter) sensors, V6 Ethernet shield and smartphone.	(i) Improving the proposed method for heart rate, temperature, blood oxygen, and	Provided speed and the precision of the outcomes, and also the maximum continuous availability and low cost to the customer.	The Arduino Ethernet shield microcontroller links the heart pulse network to the internet and sends

			breathing measurements. (ii) The physiological parameter of the patient is monitored by a doctor by sending an alert or message.		the data to the web server.
2.	Ibrahim et.al (2017)	Filters, Facial tracker, signal extractor, Blind Source Separation (BSS) with ICA.	Use the facial tracker to extract PPG signal and to acquire approximate heart rate using PPG filters and Histogram Analysis.	Impact of ROI variance for non-contact HR estimation structure over a separate distance.	The network model consists of five main steps: facial tracker, signal retrieval, Blind Source Separation (BSS) using ICA, filtering and, finally histogram analysis.
3.	Tadi MJ et.al (2016)	Seismocardiography sensor, monitor.	Heart rhythm tracking, for study of heart rate changeability and for many other medical applications.	Used for ceaseless real-time, uncluttered cardiac monitoring, cardiography on smartphones, and wearable devices for applications for health and well-being.	The wireless system needs real-time surveillance with minimal time lapses for warning links and a broad database storage.
4.	Rajput DS and Gour R (2016)	Arduino Uno, Body temperature sensor , Pulse sensor , Smartphone.	Implement real-time heart-rate data through lower power consumption programs.	In addition to congestive heart failure, diabetic neuropathy, depression, post-cardiac transplantation, SIDS susceptibility and poor survival in premature babies, decreased HRV has been shown to be a predictor of mortality after myocardial infarction.	It integrates a compact heart rate sensor with circuit amplifier and noise reduction, making it quick and easy to obtain accurate pulse readings.
5.	Kakria P et.al (2015)	wearable biosensor, Bluetooth, smartphone, web portal.	The machine is able to adapt and has the ability to derive several cardiac parameters from several patients simultaneously, such as heart rate, blood pressure and temperature.	The use of several sensors at a same time to obtain the necessary data improves the potential application of the device being built and helps to compare the accuracy of different sensors.	Wearable device connected with android and works on principle of IR sensor. The data is collected in cloud via android device for doctor to analyze.
6.	Minaie A et.al (2013)	Microcontroller, transceiver, power source, memory unit, Ethernet, WiFi, USB, serial ports, PC/laptop.	To overcome existing WSN bug and make use of feasible sensors for evaluating health in three stages.	Using a number of sensors that are relatively unsophisticated for greater range, precision and reliability at a potentially lower cost.	Wireless sensor network includes various sensor that collect data and store in database to analyze. It also gives security to data base with feasible encrypting system.
7.	Aminian M and Naji HR (2013)	Sensors, WMHRN (Wireless Multi-Hop Relay Node), PC, graphical user interface	To check various vital parameters of patients and create network using	The system is capable of carrying out long-term patient condition monitoring and is	Sensors are connected to the body of the patient and then transmitted

		(GUI), GPRS or GSM modem.	sensors connected to node. It also utilizes less energy and alarms for abnormal levels of parameter.	designed with an emergency evacuation mechanism with improved efficiency using SMS/E-mail than most current WBSN systems.	for storage and examination to the wireless base station and even to a computer.

III. RESEARCH METHODOLOGY

The methods of the proposed monitoring system that include the system architecture specified in Section 2.1, circuit diagram in Section 2.2, functioning in Section 2.3, are introduced and listed in this section.

A. System architecture

This section provides a block diagram of the design of the circuit that includes specifications for software and hardware as well as methods for monitoring the proposed device. The purpose of the device is to calculate and evaluate patients' heart pulses (HP). The findings are stored in a free ThingSpeak cloud that can be accessed remotely and based on a smartphone.

The implementation of the electronic circuit includes different types of hardware and the software components. Based on various factors such as low cost, availability, and ease of programming, these components are chosen. The hardware components required for the implementation, such as the MCU node, the pulse sensor for heart rate and the connecting wires. The necessary software components are also the Arduino IDE. The block diagram of the proposed monitoring system is presented below.

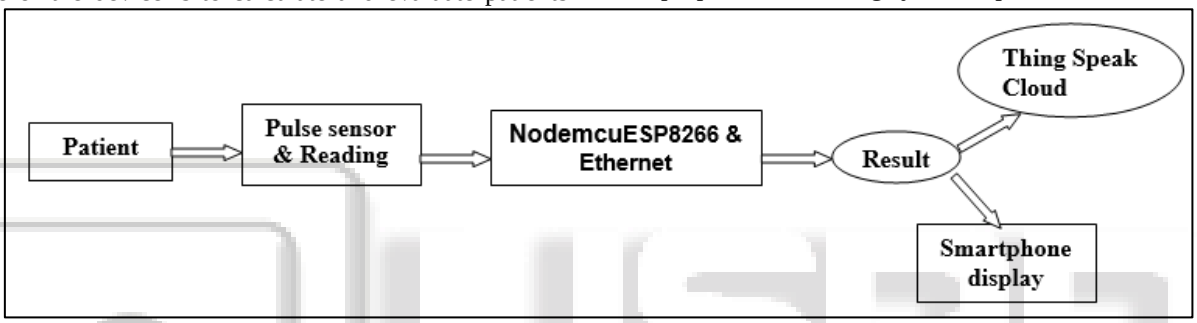

Fig. 1:

B. Circuit Diagram:

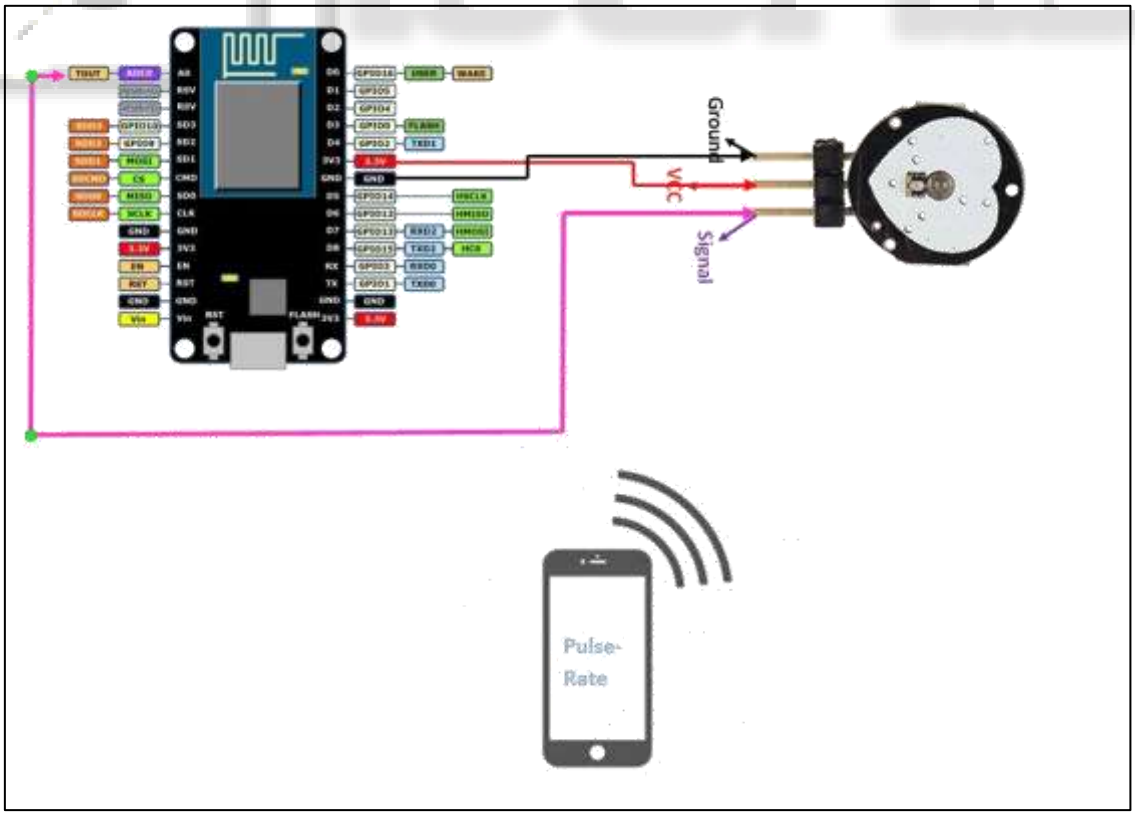

Fig. 2:

C. Working

The pulse rate sensor of device can be placed near palm of patient in vicinity of intravenous infusion which will enable patient to touch sensor with less efforts. The sensor can be coated with thin fibre film to prevent it from sweat of palm and can be attached with medical tape to finger-tip for continuous monitoring. In case of patient lying on bed, device can be attached to side of bed or supportive structure of fluid supplying through intravenous infusion.

The sensor connected to node-MCU will monitor data as per program code uploaded. The program once uploaded for continuous monitoring will have threshold value and minimum value of pulse as given by recommendation of health care professional, if overcome threshold value or falls below minimum value, it will alarm the healthcare professional and family member of patient for further steps to be taken for well-being of patient health. The data of pulse rate will be uploaded on 'things speak' cloud which offers user to upload large amount of real time data. The 'thingSpeak' cloud provides sufficient safety of data in cloud from breaching and malware as such issues can interfere with proper health care treatment to be provided to patient. The uploaded data can be accessed by electronic device of health care professional and family member of patient connected through server to keep check for abnormal pulse rate while patient is being physically isolated but virtually connected. The device should be connected with secure network to access cloud for real time data. In case the network connected to device is not safe i.e. it have malware or threat to cloud network, the cloud may restrict the device connecting and will not allow to access data. The cloud is synchronized with system globally hence it will provide accurate time for real time data monitoring in-order to prevent discrepancy if patient and health care worker are in different time zone across globe. The device does not interfere with any vital parameter of working and it does not have adverse effect on health of patient undergoing diagnosis or recovery process. It also requires less power viz. around 2W, which is feasible for patient as well as health care professional incase the cost of service is as charged by health care authority.

IV. FINDINGS AND ANALYSIS

Pulse oximetry is based on the idea that two wavelengths are mostly used to assess arterial oxygen saturation, provided that measurements are taken on the pulsatile portion of the waveform. The two wavelengths assume that there are just two absorbers, namely oxy-haemoglobin (HbO_2) and hemoglobin reduction (Hb). Proven by clinical practice, these results are based on the following:

- Skin pigments, tissue, cartilage, bone, arterial blood, venous blood can absorb light passing through the ear or finger.
- Absorption is additive and complies with the Beer-Lambert law: $A = \log T = \log l_o/I = e*D*C$.

Here I_o and I are incident and transmitted light intensities, e is the extinction coefficient, D is the depth of the absorbing layer and C is concentration.

In most design projects, there is a trade-off to what should be done with hardware or with software. In our paper, there is not much of a design comparison. The sampling and amplification must be wiped out hardware with analog values to get the right results. For the calculations and therefore the video generation, we'd like a device with enough processing power and features to perform meet all the timing requirements. In this case, the Node MCU may be a good fit at a coffee cost.

To perform on real-time service, we also carried out the delay test, which is performed to understand how long the process of transferring the necessary data from the device module to be displayed on the website by examining at the time since the information sent to the website by the device module is displayed. Testing was then carried out using a Wifi link with 10 Mbps bandwidth and an average delay of 15 seconds was analyzed.

V. CONCLUSION AND RECOMMENDATIONS

For IoT applications, we have successfully built equipment to test oxygen saturation and pulse rate. Both data are sent to the cloud successfully and are widely accessible through sites. The difference in reading with the mind-ray unit is ± 2.8 bpm for heart rate and ± 1.5 percent for oxygen saturation, as a result of the accuracy test (SpO2). The result of delay measurement was adequate to 15 seconds from the result of delay measurement by doing 15 times the data transmission test.

The IoT Enabled Pulse Oximeter developed has been a relative success compared to mainstream Pulse Oximetry and Pulse-Rate devices. Thus our aim to make the system accessible and portable has been proved and tested thoroughly. With the connection with the Internet, even remote doctors can assess the condition of the person by checking the result from the web. Hence, the device has proved to be fruitful despite its challenges.

This implementation achieves bio-signals that are trusted and tested. The verification was also carried out by making comparisons between the readings of this project and the medical instruments used by physicians and health care providers. Also certain bio-signals are successfully uploaded. This makes health practitioners capable of simultaneously tracking and diagnosing more than one health parameter. This equipment also offers an ability to track more than one case at the same time. Finally, this project can be bought at a reasonable price.

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