

IOT based Wearable for Surgical and Post-Operative Patients

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Abstract— Vital signs are an important element of monitoring the patient's progress in health during hospitalization as they allow for the quick detection of delayed recovery or unfavorable events. The vital signs are continuously or frequently, monitored during a surgical operation and post-operative period. With the already known monitoring and examination equipment, several electrodes are attached to the body of the patient, to measure electrical tension fluctuations of the body. These cables and tubes cause obstruction to each person being examined. An easy diagnosis and monitoring unit for post-operative patient is proposed in the project. The electrical cable connection of the electrodes to analysis station in existing method can be omitted, as the electrodes attached to the body being examined are equipped with its own sender units and aerials, through which the sensors are in wireless contact with the analysis station. This allows the health care provider to monitor the patient remotely with ease.

Keywords— Vital signs, post-operative patient, monitoring, analysis station, wireless, sensors, electrodes

I. INTRODUCTION

Health is very important for the well-being of a human being. Being healthy is not only beneficial for the individual, but a healthy person can contribute more to the economy. Thus, the quality of healthcare provided to the people has great significance. Over these years, the healthcare sector has evolved and has experienced developments. Hospitals have started to include new technologies to provide better diagnosis and treatment. The vitals are the basic parameters measured when a patient is admitted to any hospital. It is a quick and effective way of monitoring as it gives information about the patient's pathophysiological condition. It indicates whether the patient needs urgent help or not. It can be measured by a nurse, doctor, or any other health professional, but it is the

responsibility of the health professional to carefully interpret the data and to find out the abnormalities.

The monitoring of a patient is an essential task to provide needed care to critically ill patients. Intensive care units (ICUs), Coronary care units (CCUs), Anesthesia wards, and operating rooms are the specialized units where continuous monitoring of the vital parameters is the basic task. These specialized units are to provide constant care, close supervision, and medication to ensure the normal functioning of the patient's body. Thus, continuous monitoring of every patient is very important. Each bed in the ICU will have an acute care physiologic monitoring system that is used to continuously measure and display the number of parameters (respiration rate, blood pressure, body temperature, oxygen saturation etc.) via electrodes and sensors that are connected to the patient. It will need the patient to lay on a particular position for long periods and thus can be very uncomfortable to them. That will also require the health professional to make regular visits to post-operative ward, thus consuming more time for each patient. Ideally the nurse to patient ratio should be at least one nurse per patient, but practically, the health professionals don't get enough time with the patients due to overload. So, taking regular visits to each patient's bed in a post-operative ward can be impossible many a times. A system which enables the health professionals to do proper monitoring of their patients with less number of visits can be of great help. As technology advanced, many devices are available in the market which uses Internet of Things (IOT) to transfer data over a network without requiring human-to-human or human-to-computer interactions. The implementation of IOT in health care can help physicians to identify better treatment processes, to reach out to other health professionals no matter where they are, helps them to monitor their patients with less number of in-person visits. The doctor will be able to get hold of the data

of the patient at his table and analyze it. It can not only help the health professionals but can also help the patients by replacing the large monitors and long wires with compact devices and a limited number of cables thus making continuous monitoring easier.

II. LITERATURE REVIEW

The patient monitoring system has become one of the major developing area in the medical industry because of its innovative technology and nowadays, healthcare sensors are playing an essential role in hospitals. Studies reveal that the wireless technology network and its application in health provision is gaining popularity. Governments, insurance agencies, hospitals as well as other healthcare providers are turning to wireless technology to limit medical errors and save costs of managing patients. The growing trend in introducing the technology will help in constant monitoring of the patients while reducing the cost and increasing the quality of healthcare [1]. The six major actors in a typical scenario of healthcare are Children, Elderly and chronically ill, Caregivers, Healthcare professionals, Administrator and Developer. And the five subsystems with which these actors constantly interacts are Body Area Network (BAN), Personal Area Network(PAN), Gateway to the Wide Area Network, Wide Area Network(WAN) and End-user healthcare monitoring application. While developing devices based on new technologies like IOT one can encounter many challenges in each level.

The main challenge the traditional health care systems in hospitals especially in post-operative wards are facing is the limitations to the patient's mobility [2]. The patient's mobility in postoperative period is important in terms of standing or walking as it doesn't only reduce the risk of deep venous thrombosis but also helps the patient to return to his/her normal life.

Many medical systems nowadays use IOT in order to reduce the limitations of traditional systems. The biological parameters gathered by the sensors can be forwarded directly to IOT cloud [3] or can be shown in mobile applications like blynk [4]. The connection to internet can be either wired connection using an Ethernet cable [5] or wireless using WiFi [6]. These devices can use Raspberry Pi [7] or Arduino UNO [8] as their main microcontroller. The microcontrollers for each device is chosen based on the requirement, sometimes it will need only a single microcontroller and other times it may need two or more different microcontrollers like using both Arduino UNO and Raspberry Pi in [9].

The sensors used in each devices will also be different. The temperature sensor used for measuring body temperature can be Tsc506 [10], DS18B20 [11] and MAX30205, but MAX30205 will give more precise value since it has an accuracy of 0.1°C and a resolution of 16 bit (0.00390625°C) [12]. There are devices which could individually measure one vital parameter at a time and devices to measure more of them. A device which measures oxygen saturation, heart rate and ECG and uses wireless sensors to transmit the collected information to the data acquisition unit where the doctors can see the digitized image of the patient's parameters is shown in [13]. The system in [14] can be used to continuously measure the physiological parameters, such as Blood pressure (Systolic

and Diastolic), Pulse rate, ECG monitoring, Temperature of a human subject using Zigbee to transfer collected data. But WiFi is more preferred than Zigbee as it is faster.

Some systems uses softwares like LabVIEW for applications like measurement and testing of real time data, where the data from the sensors are given to a nearby laptop having this software using Bluetooth or using USB connection [15]. The authors of [16] has proposed a flexible healthcare system for hospitals which monitors temperature, heart beat and ECG using embedded wearable low-power sensors whose data are gathered by Raspberry Pi and are then analyzed using Labview software in nearby computer. But for remote monitoring the data should be transferred to IOT based platforms like ThingSpeak in order to analyze real time data in cloud any time anywhere [17]. A GSM based system can also provide real-time health parameters from a source (patient) to destination (family members/doctors) constantly [18] but only over some distance.

All these devices can either directly display the data measured by the sensors and let the doctors analyze it manually and detect abnormalities, or it can compare the values given by the sensor with the real reading that are acquired by traditional methods and display the change in the web server for the doctor to see and respond quickly [19]. This is possible by manipulating the software accordingly. A smart health monitoring system is proposed in [20] where the patient data which includes heartbeat, body temperature and blood pressure are given to using Arduino and Raspberry Pi and is updated on GUI which is viewed by the doctor. If any of the parameter goes above or below of predefined levels, the status will be updated and doctor can trigger button of respective tablet so that the medication box will get opened and the patient have emergency tablets in real time.

Even though the vital signs monitoring system available in market can measure a number of parameters, there is no device which can measure all of them together.

III. PROPOSED SYSTEM

The proposed project looks at the construction of a simple device specifically for surgical and post-operative patients that will be capable of transferring the data of a patient's vital signs to a remote device wirelessly. This device monitors vital parameters using a compact diagnostic device with limited number of cables and tubes. The sensors used monitors all the five vital parameters - Heart rate, respiration rate, blood pressure, oxygen saturation and temperature. It also monitors ECG patterns of the patients which makes the system different from the systems given the literature review.

All these sensors are connected to the Arduino UNO. It gathers the data from different devices according to the code.

The cuff which holds all the sensors, Arduino UNO and the Bluetooth module also has a battery pack to run the device for 1 hrs. The Bluetooth with the Arduino sends the data from the Arduino to another microcontroller NodeMCU. As the Wi-Fi module cannot be placed on the human body with the sensors as told by medical practitioners, a Bluetooth module is used to transmit sensor values to NodeMCU.

The NodeMCU establishes a connection with the IOT platform using Wi-Fi. After establishing the connection, the NodeMCU starts to send the data in the given order:- Blood oxygen level,

Blood pressure, Temperature, ECG, Respiration rate and Pulse rate.

The IOT-platform can be accessed using a laptop or a smartphone. Hence the healthcare workers looking after the patient will be able to monitor the patient's health remotely. The necessity of the project is to reduce the difficulty that is encountered by the medical experts in monitoring many patients simultaneously. The project will enable them to observe patients without having to be physically present at their bedside, be it in the hospital or in their home.

IV. COMPONENTS DESCRIPTION

A. SENSORS

1) MAX 30102

MAX30102 can be used for pulse oximetry monitoring. This sensor can be easily wearable on the finger to measure pulse of the blood. It consists of internal LEDs, optical elements, photo detectors, and low-noise electronics with ambient light rejection. It is easy to use, has I2C interface to connect to any host microcontroller. Its power supply voltage is 1.8V & 3.3V. Its operating temperature is between -40°C to 85°C. It has a fast output capability. The normal SpO₂ level of a human body is in between 95% -99%. It is used in wearable devices, medical devices, smartphones etc.

2) MAX 30205

The MAX30205 temperature sensor accurately measures temperature and supply an over temperature alarm/interrupt/shutdown output. This device converts the temperature measurements to digital form using a high-resolution, sigma-delta, analog-to-digital converter (ADC). The sensor supply voltage ranges from 2.7V to 3.3V and has a protected I2C-compatible interface that makes it suitable for wearable devices and medical applications. It has 0.1°C accuracy (37°C to 39°C).

3) ADS 1292R

This is an easy board to feature ECG/Respiration measurement capability to an Arduino, Raspberry Pi or the other microcontroller of choice. The board sports a 3.5mm interface to attach the electrodes.

The cable consists of two ECG electrodes and one DRL (Driven Right Leg) electrode placed near the pelvic for common mode noise reduction. The ADS1292R uses "impedance pneumography" to live respiration too! The method uses the change in chest impedance to arrive at respiration measures.

4) BLOOD PRESSURE SENSOR

Blood pressure is that the pressure of the blood within the arteries because it is pumped round the body by the guts. When the heart beats, it contracts and pushes blood through the arteries to the remainder of the body. This force creates pressure on the arteries. Blood pressure is recorded as two numbers—the blood pressure (as the guts beats) over the blood pressure (as the guts relaxes between beats). The unit which measures this is called Sphygmomanometer.

Monitoring vital sign reception is vital for several people, especially if the patient got high vital sign. Blood pressure doesn't stay an equivalent all the time. It changes to meet the body's needs. It is suffering from various factors including body position, breathing or spirit, exercise and sleep. It is best

to live vital sign once the person is relaxed and sitting or lying down.

The Pulse reading & Blood Pressure are shown on display using serial out for projects of embedded circuit processing and display. Shows Systolic, Diastolic and Pulse Readings. Compact design fits over the wrist sort of a watch. Easy to use wrist style eliminates pumping.

B. BOARDS

1) ARDUINO UNO

The Arduino UNO, an open-source microcontroller board supported the Microchip ATmega328P microcontroller and developed by Arduino. It is supplied with sets of digital and analog input/output (I/O) pins which will be interfaced to numerous expansion boards (shields) and other circuits. It has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a kind B USB cable. It can be powered by USB cable or by an external 9-volt battery, even though it accepts voltages between 7 to 20 volts.

2) NODE MCU

NodeMCU, a low-cost open source IOT platform. It included a firmware which runs on the ESP8266 Wi-Fi SOC from Espressif Systems, and hardware which was supported the ESP-12 module. Later, support for the ESP32 32-bit MCU was implemented.

It is a programmable, smart and Wi-Fi enabled. The device consists of 4MB storage, 80MHz of system clock, 50k of usable RAM and also an on-chip Wi-Fi Transceiver.

C. COMMUNICATION MODULE

1) BT HC-05

HC-05 module is used as Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be utilized in a Master or Slave configuration, making a good solution for wireless communication. Its operating voltage ranges from 4V to 6V (Typically +5V). Its applications include communicating with laptop, desktops and mobile phones, home automation etc.

D. BATTERY

LIPO (Lithium Polymer) 7.4V 4000mAh Rechargeable Power Bank Battery are Flat, thin, light and powerful. This battery incorporates a capacity of 4000mAh. These Batteries are mostly used in DVD, GPS, Tablet PC, iPod, Power Bank, MP4 Player, Bluetooth Speaker, Mobile Backup Power Supply, , IOT and other DIY as well as Industrial applications.

E. PLATFORM

1) UBIDOTS

The system uses Ubidots as its IOT platform to show the data received from the sensors. Its platform is used to show sensor data into information that matters for business-decisions, machine-to-machine interactions, educational research, and increase economization of worldwide resources. Ubidots exists as a simple and affordable means to integrate the facility of the IOT into a business or research. Ubidots technology and engineering stack is developed to deliver a secure, white-glove experience for the users. Device friendly APIs provides a simple and secure connection for sending and retrieving data to and from the cloud service in real-time. IOT data storage, computation, and retrieval are performance-optimized using their time-series backend services. An IOT App Builder can

customize the platform with their own HTML/JS code or can use interactive, real-time data visualization (widgets).

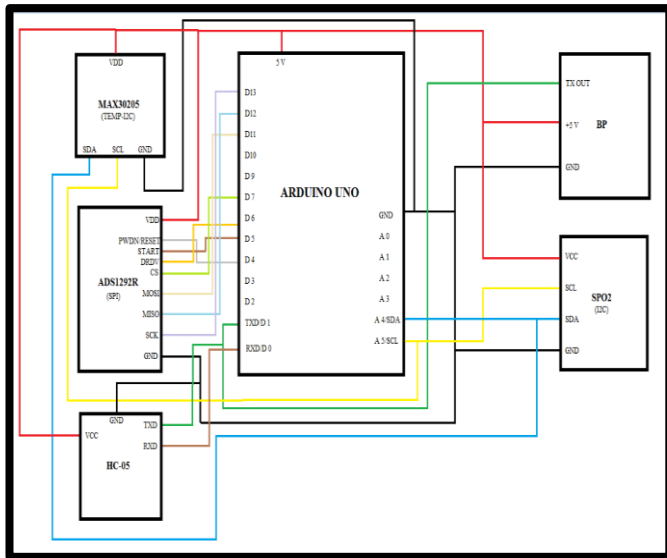


Figure 1- connection diagram of all the sensors to Arduino UNO

V. BLOCK DIAGRAM

The block diagram is divided into three parts which are patient, sensor and microcontroller, microcontroller and laptop/mobile. The patient is the subject. A device is attached to the patient, which is represented as a sensor and microcontroller in the block diagram.

The sensor and microcontroller are stitched into the handcuff with the battery. The sensors and the microcontroller on the body of the patient makes a body area network (BAN). The Body Area Network consists of the following: SpO2 sensor, Temperature sensor, ECG Sensor, Blood pressure Sensor, HC-05 Bluetooth Module, Arduino UNO and Battery pack. The sensor reads the data from the body directly and the microcontroller processes it. The sensors used like MAX30102 have microprocessors embedded in it which are used in FDA approved devices. The sensors are connected to the Arduino UNO which communicates with different sensors using different communication techniques such as I2C communication, SPI communication and serial communication. The Arduino gathers the data from different devices according to the code. The data gathered in an array is sent to another microcontroller using Bluetooth. The Bluetooth is shown using a dotted Bluetooth communication line. The system will be using Wi-Fi to send data to the IOT platform, however it can't be placed directly on the human body with the sensors as told by medical practitioners, a Bluetooth module is used instead. The Bluetooth sends the data in a form of array.

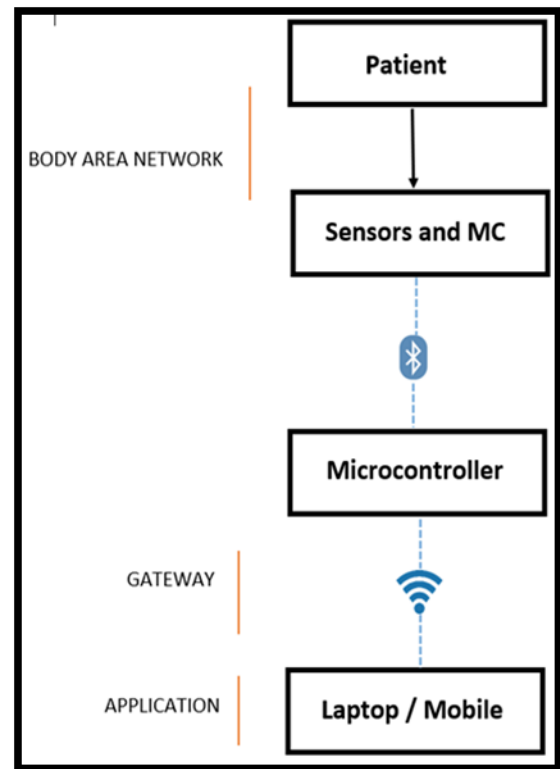


Figure 2- Block Diagram of Overall system

The second part of the system is movable. Here in the block diagram the Node MCU including the receiver Bluetooth and battery is shown as a microcontroller. The BAN and the NodeMCU come under the personal area network (PAN). The Bluetooth receives the transmitted data from the handcuff. The data received by the Bluetooth is processed in NodeMCU. The processing in NodeMCU consists of reading the data from the received array of data and sorting the data according to the type of the data. It will then connect to the IOT platform Ubidots using an API token.

The NodeMCU module acts as a gateway to connect it with IOT platform. It will create variables which will be used by the IOT platforms for identifying the data. Once the variables are made and the data are stored in the respective variables. It is sent to the IOT platform using Wi-Fi. These variables are updated with their respective data each second.

The third part is the IOT platform. This layer is called the application layer as shown in the block diagram. The platform is divided into two parts- devices and data. The variables created by the NodeMCU will be shown in Ubidots as devices. Once all the variables are formed the data will be updated on the platform every second. The platform will be showing the data using the feature called widgets. The data part of the platform has different widgets which are used to show all the values of the received variables in an easily understandable and aesthetic way.

VI. RESULTS

In this project, the team developed an IOT based wearable which uses sensors to continuously monitor the vital parameters and ECG of the surgical and post-operative patients. It provides real-time data of the patient to the doctor, so that the health care professionals can monitor and access patient's condition from anywhere at any time. This was

achieved by developing a compact device which depends on sensors and microcontrollers to transmit the data containing all the vital parameters and ECG to an IOT platform.

After successfully integrating all the sensors together, a test was conducted on the system to ensure the proper functioning. The results were satisfactory. The system can be divided into three parts, they are the transmitting section containing the sensors, Arduino UNO and battery shown in figure 2, the processing section containing receiver Bluetooth and NodeMCU shown in figure 3 and the receiving section is the IOT platform UBIDOTS, shown in figure 4.

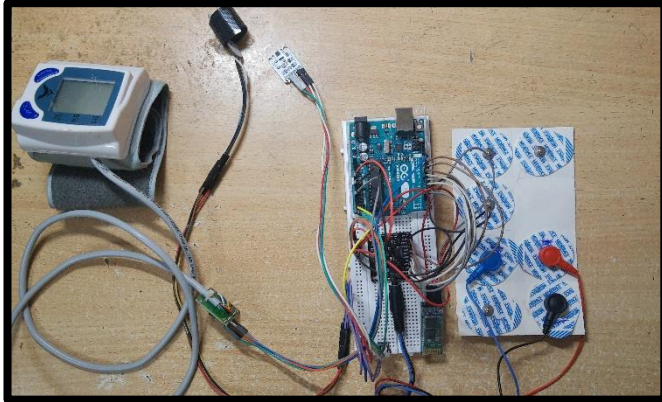


Figure 3- transmitting section

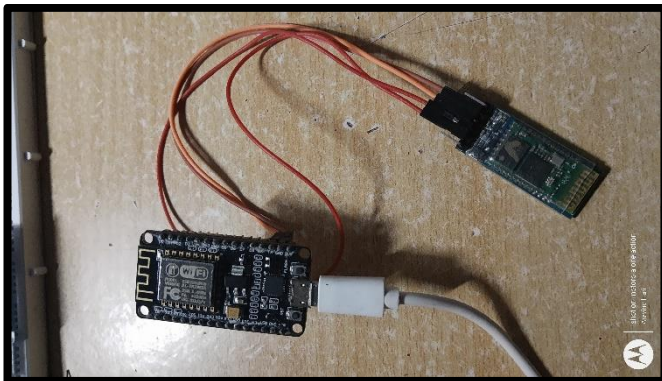


Figure 4- Processing section

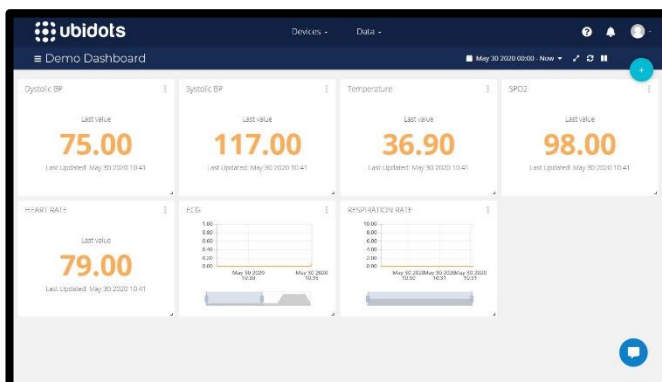


Figure 5- receiving section

The system operates well based on the steady results viewed in the IOT platform shown in Fig. 4, which is how the results are actually observed by the health professional when it comes into implementation.

The communication medium used in the project for transferring data from the handcuff to NodeMCU is Bluetooth because, the Wi-Fi module will be harmful if it has direct contact with the patients. The data transfer from NodeMCU to the Ubidots website is faster when Wi-Fi is the medium.

The IOT platform gives an alert as well alarm whenever any of the vital signs drop from the threshold value as shown in the Fig.5.

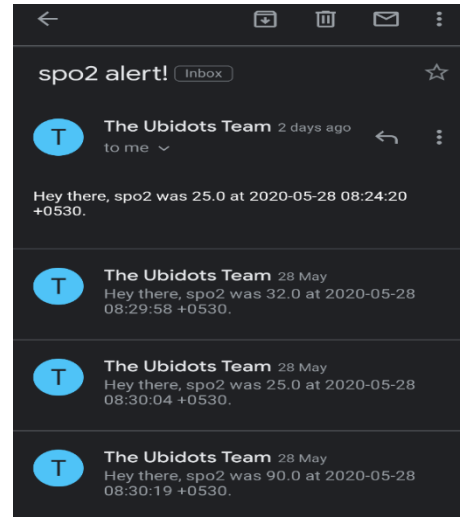


Figure 6- Alert mail sent by IOT platform when SPO2 level varies

This feature allows the healthcare professional to attend the patient in need. One of the main problem faced by the team while conducting the test is when the sensors are not properly connected to the microcontroller, the system gives out wrong readings. There is a time delay to display the readings, as some of the sensors need time to collect a set of data to produce a viable result. If the above-mentioned problems are solved, then the device perform seamlessly.

VII. FUTURE SCOPE

In the current situation of Covid'19 pandemic, the scope of such a device has increased vastly. In the hospitals across the world, the number of patients has increased by two folds than the number of beds or the healthcare workers present in the premises, which makes monitoring of each patients physically impossible. Many of these patients are elderly and people with previous medical conditions like diabetes, etc. who are highly susceptible to the disease. Monitoring of such patients has become a high priority. More than 400 million people are suffering from diseases like diabetes and there are over 2 billion elderly people living across the world, the combined number of patients in these two categories is more than the bedside units present across the world for monitoring of patients. Hence, in such a scenario, the device possesses a great use. Monitoring of all the patients can be done at the same time with this device. An alert is given to the health professional who takes care of the diseased person so that they can attend that particular patient, rather than putting themselves in harm by doing regular check.

The satisfaction of knowing that the patient is taken care of well and that the help is near keeps the patient mentally healthy. Hence, such a device is capable of revolutionizing the

field of health care. Implementation of a more comfortable arm cuff and better wiring will lead to a better product. An embedded device, which will have a microcontroller, Wi-Fi module and a Bluetooth module, can replace the current NodeMCU with Bluetooth module. A database containing patient's health records which can be accessed by the health professional with their ID if made, can help to assess the patient's situation better. The project still requires a thorough research and testing to come out as a product.

The future scope of the project is:

- Try to reduce the cost of the system when it is made as a product.
- The cuff must be smaller, comfortable and more convenient for the patient.
- Improve its efficiency and accuracy to let it become more reliable.
- Find out a better BP sensor that is attached to the arm with output cable to connect to microcontroller.

Serious potential for danger is inborn when using a device for medical purposes and thus all the medical devices must be proved safe and effective with reasonable assurance before regulating governments allow marketing of the device in the country. For the implementation of such a device, it must follow certain legal procedures, need approval from certain medical societies and associations, Standardization for different purpose such as packaging standards, biocompatibility standards, cleanliness standards, safety standards etc. Thus, all the permissions regarding the use of the device in a hospital premises are needed from the departments concerned with public healthcare.

VIII. CONCLUSION

Wearable health monitoring devices are one of the most promising applications of the Internet of Things in medical field. Even though there are many devices to measure a person's vital parameters individually in a surgical and post-operative period, there is no device that could continuously monitor a patient's vitals without attachment of cables from the bedside monitor. In the existing system, wired sensors connected to large devices on the other end is attached to the patient, which insists on periodic monitoring. The device proposed in the project is an innovative system that could measure the vital parameters and ECG, and then transmit it to the doctor's tab or an IOT platform which can be accessed by the doctors. Thus, the real-time information will be available to the doctors no matter where they are.

In order to complete the project efficaciously, the work was divided into three phases and in each phase proper testing was conducted to verify the functionality of the system. The sensor values of the system were compared with the values given by traditional methods to ensure that the system is accurate. Even though there are many devices with the latest technology to measure the vitals individually, they are not widely used in hospitals, as more research, testing, standardization and approval from medical associations are required before implementation of this device. Hence, most of the hospitals are still using conventional methods for diagnosis as accuracy in vital parameters very important in medical field. Therefore, in order to implement the device proposed, more research and testing is required in the future.

REFERENCES

- [1] Alemdar, Hande, and Cem Ersoy. "Wireless sensor networks for healthcare: A survey." *Computer networks* 54, no. 15 (2010): 2688-2710.
- [2] Aziz, Omer, Benny Lo, Rachel King, Ara Darzi, and Guang-Zhong Yang. "Pervasive body sensor network: an approach to monitoring the post-operative surgical patient." In *International Workshop on Wearable and Implantable Body Sensor Networks (BSN'06)*, pp. 4-pp. IEEE, 2006.
- [3] Uddin, Mohammad Salah, Jannat Binta Alam, and Suraiya Banu. "Real time patient monitoring system based on Internet of Things." In *2017 4th International Conference on Advances in Electrical Engineering (ICAEE)*, pp. 516-521. IEEE, 2017.
- [4] R.Priyanka, M.Reji . "IOT Based Health Monitoring System Using Blynk App". *International Journal of Engineering and Advanced Technology (IJEAT)* ISSN: 2249 – 8958, Volume-8 Issue-6, August 2019.
- [5] Kshirsagar, Pravin, Akshay Pote, K. K. Paliwal, Vaibhav Hendre, Pranav Chippalkatti, and Nikhil Dhabeekar. "A Review on IOT Based Health Care Monitoring System." In *ICCCE 2019*, pp. 95-100. Springer, Singapore, 2020.
- [6] Selvi, M. Chengathir, T. D. Rajeeve, A. John Paul Antony, and T. Prathiba. "Wireless sensor-based healthcare monitoring system using cloud." In *2017 International Conference on Inventive Systems and Control (ICISC)*, pp. 1-6. IEEE, 2017.
- [7] Kumar, R., and M. Pallikonda Rajasekaran. "An IOT based patient monitoring system using raspberry Pi." *2016 International Conference on Computing Technologies and Intelligent Data Engineering (ICCTIDE'16)*. IEEE, 2016.
- [8] Kaveri S, Lincey Veronica A, Monisha H, Aarthy Suganthi Kani, "An IOT based Patient Health Monitoring System using Arduino UNO", *International Journal of Science, Engineering and Technology*.
- [9] Uplenchwar, Kartikee, and Aditi Vedalkar. "IOT Based Health Monitoring System using Raspberry Pi and Arduino." *International Journal of Innovative Research in Computer and Communication Engineering* 5.12 (2017).
- [10] Liu, Jun, Fei Xie, Yaqi Zhou, Qian Zou, and Jianfeng Wu. "A wearable health monitoring system with multi-parameters." In *2013 6th International Conference on Biomedical Engineering and Informatics*, pp. 332-336. IEEE, 2013.
- [11] Amandeep Kaur, and Ashish Jasuja. "Health monitoring based on IOT using Raspberry PI." *2017 International Conference on Computing, Communication and Automation (ICCCA)*. IEEE, 2017.
- [12] Sudha, S., P. Shruthi, and M. Sharanya. "IOT BASED MEASUREMENT OF BODY TEMPERATURE USING MAX30205." 2018.
- [13] Ajith.S, Praveen Raj.K, Syed Ibrahim.I, Mr.Nagaraj.M, "WIRELESS MONITORING OF PATIENTS BY IOT THROUGH PULSE-OX & HEART RATE SENSOR", *International Journal of Pure and Applied Mathematics*, Vol. 119, No. 15, pp: 973-979, 2018.
- [14] Patil, Harshavardhan B. "Prof. VM Umale, "Arduino Based Wireless Biomedical Parameter Monitoring System Using Zigbee"." *International Journal of Engineering Trends and Technology (IJETT)– Volume 28* (2015).
- [15] Abdullah, Amna, et al. "Real time wireless health monitoring application using mobile devices." *International Journal of Computer Networks & Communications (IJCNC)* 7.3 (2015): 13-30.
- [16] Rajasekhar, Konala Reshma & K. "Design of Medical Data Monitoring by Using Raspberry Pi." *International Journal of Research* Vol. 04, No. 2, February 2017.
- [17] Sammeta Lalitha , Mr.D.Shekar Goud, "Web Based Smart Real Time Health Care Monitoring and Alert System Using Internet of Things (IOT)" *International Journal of Engineering Trends and Applications (IJETA)*, Vol. 5, issue- 3, June 2018.
- [18] Biswas, Anagh, et al. "Real time health monitoring of patients from a remote place." *2017 1st International Conference on Electronics, Materials Engineering and Nano-Technology (IEMENTech)*. IEEE, 2017.
- [19] Swaroop, K. Narendra, Kavitha Chandu, Ramesh Gorrepotu, and Subimal Deb. "A health monitoring system for vital signs using IOT." *Internet of Things* 5 (2019): 116-129.
- [20] Khan Adil Parvez and Prof. J.D. Bhosale, "Smart Health Monitoring and Controlling Using Raspberry Pi3", *International Journal of Electronics, Electrical and Computational System*, Vol. 7, issue-4, April 2018.