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Internet of Things Based Monitoring System for Comatose Patients

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Abstract- **Internet-of-Things and machine learning promise a new era for healthcare. The emergence of transformative technologies, such as Implantable and Wearable Medical Devices (IWMDs), has enabled collection and analysis of physiological signals from anyone anywhere anytime. Machine learning allows us to unearth patterns in these signals and make healthcare predictions in both daily and clinical situations. This broadens the reach of healthcare from conventional clinical contexts to pervasive everyday scenarios, from passive data collection to active decision-making. This project, Internet-of-Things Based Monitoring System for Comatose Patients is a working model which incorporates sensors to measure parameters like body temperature, pulse rate and movement. A micro-controller board is used for analyzing the inputs from the patient and any abnormality felt by the patient causes the monitoring system to give an alarm. Also all the process parameters within an interval selectable by the user are recorded online. This is very useful for future analysis and review of patient's health condition.**

Index Terms— **Arduino Uno, Artificial intelligence, Internet of things, Machine Learning**

I. Introduction

Healthcare is one of the global challenges for humanity. According to the constitutions of the World Health Organization (WHO) the highest attainable standard of health is a fundamental right for an individual. To keep individuals healthy, an effective and readily accessible modern healthcare system is a prerequisite. A modernized healthcare system should provide better healthcare services to people at any time and from anywhere in an economic and patient friendly manner. According to Shivleela and Dr. Sanjay (2018) in traditional method, doctors play an important role in health check up because this process requires a lot of time for registration, appointment, check up and then reports are generated later. Due to this lengthy working process people tend to ignore the checkups or postpone it. According to Sathya , Madhan and Jayanthi (2018), the increased rate of medically challenged people has made remote healthcare become a part of our life.

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According to Naveen and Hardeep (2011), Coma is sometimes called persistent vegetative state and is a profound or deep state of unconsciousness, Persistent vegetative state is not brain-death. An individual in a state of coma is alive but unable to move or respond to his or her environment. Coma may occur as a complication of an underlying illness, or as a result of injuries, such as head trauma. Because of expanding work cost, medical institutions would constrain to decrease nursing staff for patients. There are lots of IOT devices these days used to monitor the health of patients over the internet. Health experts are also taking advantage of these smart devices to keep an eye on their patients. With lots of new healthcare technology start-ups, IOT is rapidly revolutionizing in the healthcare industry (Rishabh, 2018) In this paper, a secured IOT-based healthcare monitoring system for coma patients is introduced. To achieve system efficiency simultaneously and robustness of transmission within public IOT-based communication networks, a robust asymmetric cryptograph is used to construct two communication mechanisms for ensuring transmission confidentiality and security which can help patients to be monitored remotely. By this, on the basis of derived data if a patient is in a critical situation, an immediate instruction can be given to the person who is in charge. The system will play a vital role to reduce labor cost, ease of access from anywhere at any time and will be helpful in making effective decision.

Internet of Things (IOT) is a growing concept which has an effect on many aspect of human life. According to Fahad, Faizan, Deepak, Touqueer (2017) Internet of Things (IOT) is the internetworking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings and other items embedded with electronics, software, sensors, actuators and network connectivity that enable these objects to collect and exchange data. IOT is also referred to as an integrated information network of future internet where physical and virtual things with identities, physical attributes and intelligent interfaces are seamlessly connected. In the recent years use of wireless technology is increasing for the need of upholding various sectors and IoT groped the most of industrial area specially automation and control. Biomedical is one of the recent trends to provide better health care. Not only in hospitals but also the personal health care facilities are opened by the IoT technology. Among the applications that Internet of Things (IoT) facilitated to the world, Healthcare applications are most important. In general, IoT has been widely used to interconnect the advanced medical resources and to offer smart and effective healthcare services to the people. The advanced sensors can be either worn or be embedded into the body of the patients, so as to continuously monitor their health. Various processes of different concepts including data acquisition, data transmission and data analytics enable IOT based system to support smart solutions especially for health care. A microcontroller-based device with appropriate biomedical sensors will be attached to patient to provide constant cloud-based monitoring. The vital signs i.e. temperature and pulse rate of the human body which are major clues to detect any health problem will be sensed by respective sensors supported by NodeMCU in a Wi-Fi environment and the data will be sent to Thing Speak cloud where the data will be analyzed to look for any irregularity. According to Israt, Shadman, Rifat and Mashwab (2018) the death rate of people dying each year is 55.3 million or 1,51,600 people dying each day or 6316 people dying each hour which is a big issue all over the world. So in other to reduce the rate of death especially in coma patients this system is proposing a model which will monitor patients even when medical personnel's are absent. It will also reduce valuable time for doctors and nurses, they don't need to wait for the reports because the sensors are giving real time data. The model would be very effective for hospitals in rural areas which are short-staffed.

1.2 Aim and Objectives of the Study

The aim of this research work is to develop an IOT based monitoring system for comatose patient with the following objectives

i. To reduce the time lag in between actual requirement and service treatment

ii. To monitor the body movement of the coma patient and send the real time notification to doctors

iii. To reduce cost

iv. To provide accurate detection

1.3 Statement of the Problem

The following problems are associated with the existing system:

i. Inability of medical personnel's to keep track of changes in the health parameters of the patient over a period of time

ii. Lack of accurate prognosis (prediction)

iii. Lack of adequate routine checkup by medical personnel

iv. Inability of medical personnel's to monitor the patient 24/7.

1.4 Significance of Study

The result of this study will be of great benefit to:

Doctors/Nurses and the patients because IOT monitoring system proves really helpful when we need to monitor, record and keep track of changes in the health parameters of the patient over the period of time.

Doctors can take the reference of these changes or the history of the patient while suggesting the treatment or the medicine to give to the patient

Hospital stays are minimized due to remote patient monitoring

Hospital visits for normal routine checkups are minimized

Patient health parameter data is stored over the cloud. It is more beneficial than maintaining the records on printed papers kept in files or even the digital records which are kept in a particular computer, laptop or memory device like pen-drive because there are chances that these devices can get corrupt and data might be lost, whereas in IOT, the cloud storage is more reliable and has minimal chances of data loss.

1.5 Scope of Study

The aim of this project is to build an IOT based monitoring system that monitors various parameters like temperature pulse rate and movements that occurs in a coma patient and alerts the doctors and nurses.

II. Literature Review

Present day health care applications of wireless sensor networks (WSN) aim to monitor heart troubles, breathing issues, panic response, and stress levels. Even though numerous studies focus on technical, monetary, and social issues, the technical sprints need to be resolved to have reliable, secure, flexible and power-efficient WSN. The integration of existing medical technology with wireless network in specialized areas is expected to be witnessed soon. Small wearable nonintrusive sensors will facilitate large data to be collected automatically. This will reduce regular visit to clinics and hence the expenditure. (Swaroop, Chandu and Gorrepotu,2019).

Future works in this field of research will benefit the entire health field. A smart vest is another technology evolving as an essential system that can be worn for physiological monitoring. Different sensors can be integrated into the wearable and at the same time gather bio-signals in an unobtrusive and non-invasive way. The emerging technology for communication in healthcare is by mobile monitoring systems. Self-management of patients was possible with a phone call and SMS. This method produced satisfactory changes in patient self-efficacy, adherence to treatment and behavioral changes. A clinically validated and flexible frame-work, performing real-time analysis of physiological data to monitor patient health conditions has also been developed. Data mining techniques are used for analyzing the data collected by sensors. Real-time processing was performed, and alerts triggered in critical situations. In a unique approach to measure the heart rate by a non-contact and non-invasive device, a CCD(charged coupled device) camera was employed in a trial of 14 Asian participants. Airstrip Technologies developed using AppPoint software platform, a new monitoring system that can be as good as smart phones and personal computers. According to Topol, acceptance of mobile phones in healthcare is possible because of ever-growing use of smart phones, enhanced bandwidth with third and fourth generation (3G and 4G) mobile data networks and computing power comparable to that of a personal laptop computer. There is a competitive market of medical technology using information technology for healthcare provision. Healthcare systems are advancing for cloud adoption and artificial intelligence driven analytics for diagnosis. A system for prediction and support for aged individuals suffering from memory impairment was implemented using information from unimpaired cases. IoT research is clearly geared towards engaging cloud technologies with evolutionary computing tools to deliver urgent or monitored medical assistance. Integrating different modes of communication for health monitoring would help to overcome drawbacks in communication. BLE (Bluetooth low energy) can be exploited for short-range transmission, Wi-Fi over the Internet and SMS when the Internet is inaccessible. Swaroop *et al*. (2019).

Now-a-days increasing of technologies health experts is taking the great advantage of these electronic gadgets. IoT (Internet of things) devices are highly used in medical sector. In this paper, the project is about health monitoring system especially for coma patients. In rural area because in rural area number of doctors is less than urban area. In rural area, medical equipment is not available except government hospital. So, the number of patients is higher than government hospital. Also, the equipment is expired in many cases. So, if any emergency call needed, this hardware device will immediately send the report to the doctors or intern doctors. Doctors will do their rest of works by their reports. But in present time, no remote HRV (Heart Rate Variability) analysis systems for coma patients is available to help the doctors to track down the progression of the patient's condition or critical events in rural area.

IoT is nothing but an advanced concept of ICT (Information Communication Technology). Raspberry pi component is more costly than Arduino component device. Technologies are broadly expanded in web based or on line system. Now- a - days collecting real time is vital. When a patient with a critical condition is discharged from the hospital, he or she needs to be checked up on a regular basis. That is why IoT based heath monitoring system is best option for rural area. The Internet of Things digitizes physical assets – sensors, devices, machines, gateways and the network. It connects people to things and things to things in real time. A typical IoT network can grow rapidly, resulting in an experimental increase in the variety, velocity and the overall volume of data. This data opens opportunities for significant value creation and revenue generation. But the real challenge for IoT environments is how to analyze the large volume of information from all sources and take action in real time.

The complexity of IoT combined with the high expectations created by the Internet, Mobile, and 24x7 IT environments has made the need for new analytics approaches and technologies more urgent. Achieving desired business objectives requires the ability to act in real-time to take advantage of opportunities and address problems quickly. In the pre-IoT era, an issue in a typical supply chain scenario could be addressed in 2-3 day cycles for satisfactory results. But in IoT, time to action is in minutes, seconds, or microseconds – 30 minutes to provision electric service, 30 seconds to act on information from devices, 5 milliseconds to address a security breach. This explosion of data and the high expectations in the IoT environment means the value of data will slip away quickly. The importance of time-to-action for IoT applications can be seen in a wide array of applications and use cases. Broadly speaking, these applications can be grouped into three categories:

1) Operations and fulfillment are a convenient place to prove out efficiency gains.

2) Customer-focused sales and marketing applications have the potential to increase customer satisfaction and long-term growth.

3) Innovation in new products and services can drive new revenue and business value.

There are also specific use cases within these applications:

i. Predictive Maintenance

ii. Demand/Supply Optimization

iii. Predictive 1 to 1 Marketing

iv. Outage Management Addressing the critical time-to-action requirement for these use cases and applications in IoT demands an advanced analytics solution that

1) Unifies historical, real-time streaming, predictive, and prescriptive analytics.

2) And provides faster analytics and smarter actions. Israt, Navid, Reza, Mahbub (2018).

2.1 Machine learning and IoT Based Smart Health

The human body is constantly providing information about one’s state of health. This information is obtained through systems or devices that measure capture or detect values and variables at specific points of the body in an invasive or non-invasive manner. Healthcare personnel use the values of biomedical variables to make decisions on diagnoses and treatments in order to improve patients’ health. The IoT makes it possible to interconnect, detect, identify, and process data between objects or services to fulfill a common objective. The main advantages of IoT in healthcare are the monitoring, analysis, diagnosis, and control of conditions and the generation of recommendations to prevent them. However, the objects used in the IoT have limited resources, so it is necessary to consider other alternatives for data analysis, such as machine learning. Machine learning is a subset of artificial intelligence that consists in studying the algorithms and statistical models used in computer systems in order to achieve specific objectives effectively, based on patterns and inferences. At present, there are several challenges in the health sector that provide areas of opportunity for the IoT and machine learning to provide solutions or alternatives that contribute to improving healthcare and quality of life. (Machorro-Cano, Alor-Hernández , Paredes-Valverde, Ramos-Deonati, Sánchez-Cervantes and Rodríguez-Mazahua, 2019).

Most healthcare institutions rely on conventional information systems that are difficult to implement due to the inability to meet the demands of end-users. Hence, legacy information systems do not conform to recent developments in ICT. Technological advances can better deal with operational problems in healthcare delivery with the application of computational tools to hospital activities. In a healthcare system, ICT provides health services to anyone at any time and any location. ICT advances enable patients, who are remotely located, to perform their routine activities in a daily basis.

In a modern health care, technological advances can better deal with operational issues, such as physician and patient relationship improvement , easy access to and sharing of information among medical care units and people who are close to patients (e.g., relatives), high mobility for uninterrupted monitoring of patients’ health status not limited to hospital facilities, involvement of external health care professionals in treatment and diagnosis of patients, emergency situation alerts to health care professionals, and so on.

Wearable biomedical sensors are very useful due to the need for monitoring of vital signs, patients' activities, and real-time health parameters, and without hindering their movements. Vital signs differ based on patients' activities, smoking, sleeping habits, temperature, and others. If heart rate increases while a patient sleep, it is recognized as an abnormal case. While conventional health care assistant (HCA) systems are standalone applications that rely on local devices and servers, they are not flexible in monitoring different patients with distinctive health issues.

There are several user roles involved in the remote care platform; they are mainly the nursing staff, agent servers, physicians, platform administrators, patients, sensors, and foreign care.

- Nursing staff: They frequently contact physicians and discuss appropriate medical intervention and referral, regular follow-up, and try to understand the changes in the disease, while also handle inspection reports, clinical plans, and other treatment stages. In addition, nursing staff conduct monitoring and tracking through telephone interviews. Moreover, they play a crucial role in distant care in the form of frequent contact with patients, as well as the tracking of personal health records.
- Agent Server: to ensure the system operates automatically, the agent server allows the message to automatically flow to the correct object, such as the monitoring of comatose patients, in which the guidelines can be set in advance. Thus, when the patient regains consciousness, the agent server sends a notification informing the physician or caregiver.
- Physician: in abnormal physiological information, physicians along with nurses discuss and consult other relevant medical treatments to take appropriate intervention measures with the inclusion of the personal follow-up records of patients.
- Platform Administrator: is responsible for operating the platform, including abnormal message monitoring, network monitoring, software deployment, hardware sensor management, and data transmission.
- Patient: patients receive medical treatment with the use of a sensing device that helps measure blood pressure and pulses through an Electrocardiogram Sensor (ECG).
- Sensor: an instrument collecting the patients' physiological data, which refers to a blood pressure monitor or thermometer. The sensor transmits the data to the nearby data receiving station through the wireless communication pipe at a fixed time. - Foreign care: they are responsible for the first-line contact with patients. Hence, through foreign care, patients are trained to wear the sensing devices in a correct way to ensure the system is connected, runs smoothly, and can receive the alert signal in the emergency. (Su, Hajiyev and Fu, 2019)

2.2 IoT Based Patient Monitoring

According to Israt *et al*. (2018), 4.9 million people died from lungs cancer, overweight 2.6 million, 4.4 million for elevated cholesterol, 7.1 million for high blood pressure. Patients who need a regular monitoring by doctors to discuss the state of health condition, IoT based patient Monitoring system is useful for them. The main concept of IoT is defined as the integration with electronic devices that connect with doctors or health monitoring persons. IoT the term was first mentioned by Kevin Ashtor in 1998. IoT can be divided in three sections.

1. Internet – Oriented Middle ware.
2. Things Sensors Oriented.
3. Knowledge Oriented Semantics.

First as hardware layer which allow the interconnection by using sensors and technologies. Sensors are used to measure Heart Beat, ECG, and Temperature etc. The main purpose of this IoT is to improve a solution based on ontology with ability to monitor the health status.

2.3 ECG (Electrocardiograph)

ECG or Electrocardiography is a system which can record and measure the electrical activity of the heart over a period of time using electrodes on the skin. Bio monitoring electrodes have passed through a great evolution and progress from 19th century. In 1883, Carlo Matteucci who was a professor of physics at the University of Pisa, first time showed and proposed sensors that watch and monitor the electricity in human body periodically. In 1887, Augustus D.Waller was presented and published the first human electrocardiogram. He was British physiologist. In 1901, Willem Einthoven made re infrastructure of Waller's technology. Here, he used fine quartz coated with silver in a device which is called the string galvanometer. Einthoven won noble prize for formulate and create the electrocardiograph. In present time, bio monitoring electrodes use in ECG which is made of a plastic substrate covered with a silver chloride ionic compound. The Ag/Acl electrode is mostly used for all the application in bio medical electrode system. These electrodes create an electrical potential and ionic activity in living cells. After connecting the human body, these potentials are demonstrate on the body surface.

The heart starts activation at sino-atrical node which is build and produces heart frequency about 70 cycles per minute. This activation generated to the right and left muscle tissues. There is delay which use to allow the ventricles to fill with blood from atrial contraction in the ventricular node. These activities help to pump blood to the aorta and to the rest of the body. At last, the repolarization happens and the cycle is repeated time after time. When the cycle take place, the transmembrane potential which measure the voltage difference between the internal and external spaces of the cell membrane create a changes at the each stages. Voltages differences are measured by using the surface electrodes. These different peaks P, Q, R, S, T and U are detected in these stages.

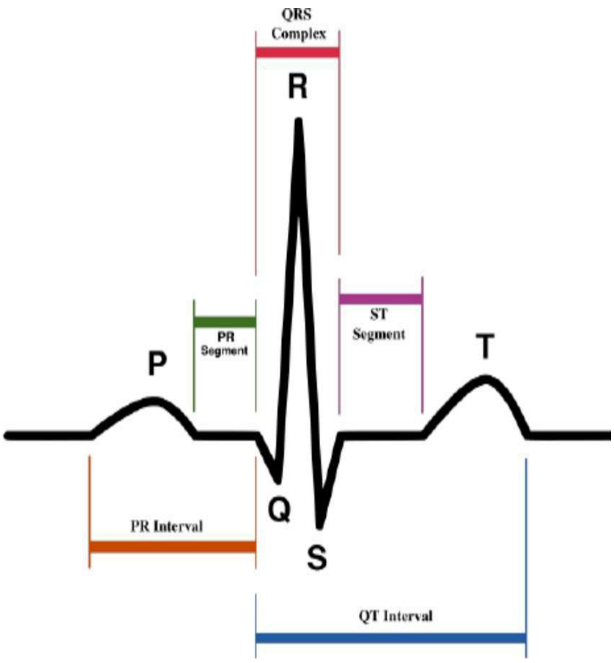


Figure 1 Normal sinus rhythm ECG Israt Jarin Hoque, Md.Shadman Navid, Rifat Binte Reza, Mashwab Ibna Mahbub, IoT based patient monitoring system (2018).

2.4 ECG sensor generated within the body

The heart has four chambers. The upper two chambers (left/right atria) are section focuses into the heart, while the lower two chambers (left/right ventricles) are shrinkage chambers sending blood through the course. The dissemination is splitted into a "circle" through the lungs (aspiratory) and another "circle" through the body (foundational). The cardiovascular cycle alludes to an entire pulse from its age to the start of the following beat, containing a few phases of filling and purging of the chambers. The frequency of the cardiac cycle is reflected as heart rate (beats per minute, bpm). The heart works naturally – it is self-energizing (different muscles in the body require anxious jolts for excitation). The rhythm of compressions of the heart happen unexpectedly, yet are touchy to apprehensive or hormonal impacts, especially to thoughtful (stimulating) and parasympathetic (decelerating) air conditioning activity.

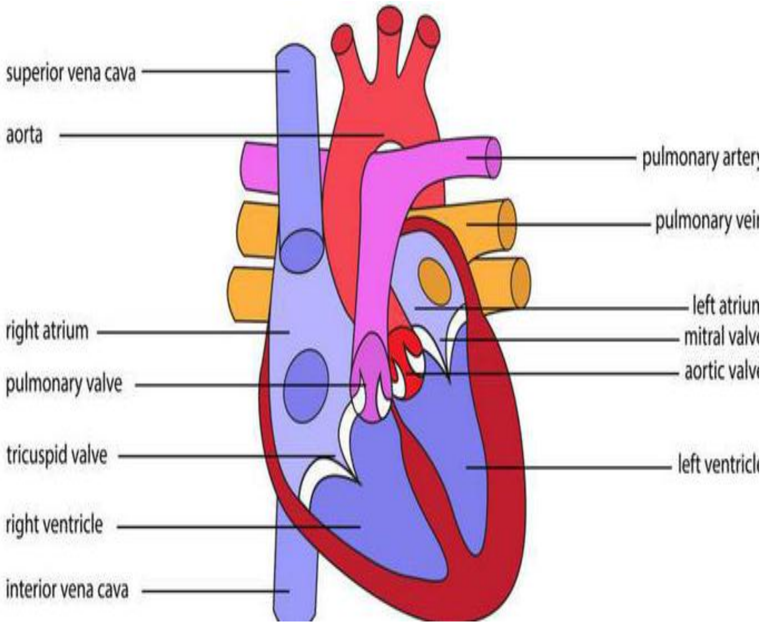


Figure 2: Heart Diagram Israt Jarin Hoque, Md.Shadman Navid, Rifat Binte Reza, Mashwab Ibna Mahbub, IoT based patient monitoring system (2018).

2.5 ARDUINO

Arduino provides open source electronics prototyping platforms based on flexible, easy to use hardware and software. It is a microcontroller development board based on the Atmel ATmega 328 MCU. The Arduino UNO has 14 digital input or output pins (of which 6 can be used as PWM outputs), 6 analog inputs, 16 mega Hz crystal oscillator, a USB connection, a power jack, ICSP header and a reset button. This Arduino MCU board contains everything needed to support the microcontroller. Simply connected to a computer with a USB connection, power it with an AC to DC adaptor or battery to get started. The Arduino UNO differs from all preceding boards in that it does not serial convertor. The Arduino UNO MCU board can be powered via the USB connection or with an external power supply. The power source is selected automatically.

2.6 Operational Instruction

After power on, one hand finger will touch the H-beat sensor and the LED light will start blinking continuously after 1000 milliseconds. After 20 seconds, the person will get the heart beat value that LED light will blink. It means the operation is progressing on until power off. When the U-H Beat button press the value will directly send on mobile message, android application as well as web page within 3 seconds. For ECG measurement, the ECG sensor attached with chest and push button 'ECG'. The receiver will get the result in web page and android application with time and date within 3 seconds.

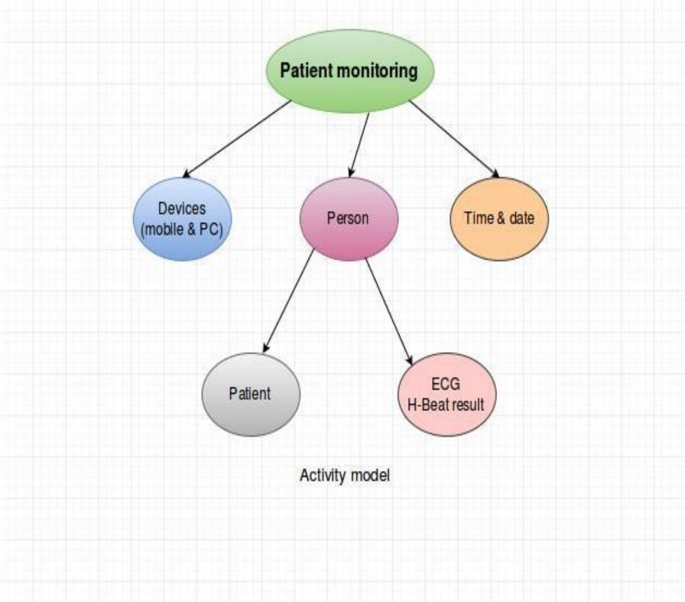


Figure 3: Operational Instruction Israt Jarin Hoque, Md.Shadman Navid, Rifat Binte Reza, Mashwab Ibna Mahbub, IoT based patient monitoring system (2018).

2.7 Heart Beat

Heart rate known as pulse rate is the number of times a person's heart beat per minute. Normal heart rate varies from person to person but a normal range for adults is 60 to 100 beats per minute. Also normal heart rate depends on the individual age, body size, heart condition also if the person is sitting or moving, medication use and even air temperature. Emotion can vary heart rate for example getting excited or scared can increase the heart rate. According to American Heart Association (AHA) well trained athlete may have a normal heart rate of 40 to 60 beats per minute. There are 4 steps to measure heart rate:

1. Writs
2. Inside of an elbow
3. Side of the neck
4. Top of the foot

How to measure accurate heart rate: Put two fingers over one of these areas and count the number of beats in60 seconds. Also measure 20 seconds and multiply by three which is easier than first step.

Resting heart rate: When a person is in resting mode, it is the best time to measure heartbeat. According (AHA) for adults and older normal heart rate is between 60 and 100 beats per minute (bpm). But below 60 (bpm) doesn't mean the person has health issue problem. Active people have lower heart rates because their muscles don't need to work as hard to maintain a steady beat. Maximum and target heart rate: A person's target heart rate zone is between 50 percent and 85 percent of his or her maximum heart rate. According to (AHA) 30 year old person would be between 50 and 85 percent of his or her max heart rate.

Table 1. Rate of heartbeat per minute

Age	Target HR Zone 50-85%	Average Maximum Heart Rate, 100%
20 years	100-170 beats per minute (bpm)	200 bpm
30 years	95-162 bpm	190 bpm
35 years	93-157 bpm	185 bpm
40 years	90-153 bpm	180 bpm
45 years	88-149 bpm	175 bpm
50 years	85-145 bpm	170 bpm
55 years	83-140 bpm	165 bpm
60 years	80-136 bpm	160 bpm
65 years	78-132 bpm	155 bpm
70 years	75-128 bpm	150 bpm

2.8 Communication between Hardware and Software

In this project, communication between hardware and software in serial data communication is
used. Serial data communication uses two methods.

1. Synchronous
2. Asynchronous

In where, synchronous method transfers a block of data at a time. Asynchronous method transfers a single byte at a time. It is possible to write software to use either of the methods. The program can be tedious and long that's why special IC (integrated circuit) chips is made by many manufactures for serial data communication. These chips are commonly referred to as Universal Asynchronous Transmitter / Receiver (UART).

Persistent aberration of heart rate may be an indication of serious health complication such as coronary Artery Diseases, Tachycardia and Hpertension. Hence heart rate monitoring is extremely essential in order to keep track of one's heath. Unlike traditional method like Electro-cardiogram which are complicated and non-portable, there is a need for a simple and affordable heart rate measuring device. This paper expounds the design and working of a device based on principle of Photoplethysmography. It is an economical user friendly and low power consuming device. The performance of the device was evaluated and its results were compared with the reports of conventional heart rate monitor, deviation was absorbed minimal. In their project they monitor the heart beat rate of the user by pulse sensor and when the pulse rate reach above or below the given threshold value. Then Heart rate is displayed in the LCD it then proceeds to alert by an alarm and SMS sent to the mobile phone of the medical expert or health personnel, if and only if the threshold value of the heartbeat rate is maximally exceeded. This system designed and developed a reliable energy, efficient for sending alert message to the concern person when person is in coma. The system used smart sensors like flex sensor, MEMS. Body sensor and eye blink sensor. Whenever person moves any finger, any eye lid and tilt the body towards right or left side, the flex sensor, eye blink sensor and MEMS sensor detects the movement respectively, and alert to the concern person through GSM. It sends message through the GSM modem to the concern person showing the status of the body. The system monitor physically 24*7 for getting the improvement of comatose patient for further treatment.

III. METHODOLOGY, SYSTEM ANALYSIS AND DESIGN

3.1 Methodology

Methodology is a way of software development. A methodology is a formalized approach to implementing the SDLC (i.e., it is a list of steps and deliverables). There are different system development methodologies, and they vary in terms of the progression that is followed through the phases of the SDLC. Some methodologies are formal standards used by government agencies, while others have been developed by consulting firms to sell to clients. Many organizations have their own internal methodologies that have been refined over the years. (Alan, Barbara, Roberta, 2012). Agile, Unified Process, Structured System Analysis and Design Method, etc are some of the methodologies available.

Agile is an iterative approach to project management and software development that helps teams deliver value to their customers faster. An agile team delivers work in small but consumable increments. Requirements, plans and results are evaluated continuously so teams have a natural mechanism for responding to change quickly. Agile isn't defined by a set of ceremonies or specific development techniques. Rather, agile is a group of methodologies that demonstrate a commitment to tight feedback cycles and continuous improvement.

3.1.1Advantages of Agile Methodology

1. More flexibility
2. More productivity
3. More transparency
4. Products of superior quality
5. Decreased risk of missed goals.

3.1.2Disadvantages of Agile Methodology

1. Teams get easily sidetracked due to lack of processes
2. Long-term projects suffer from incremental delivery
3. The level of collaboration can be difficult to maintain.

Structured System Analysis and Design Method (SSADM) is a set of standards for systems analysis and application design. It uses a formal methodical approach to the analysis and design of information systems. The Structured System Analysis and Design Method is an open methodology based on the waterfall model. It follows the waterfall life cycle model starting from the feasibility study to the physical design stage of development. SSADM breaks up a development project into stages, modules, steps and tasks.

3.1.3Advantages of Structured System Analysis and Design Method

1. Well documented
2. Thorough roadmap/guidelines (i.e. it's hard to go off track)
3. High quality system is delivered at the end of the project
4. Suits hierarchical organizations like government bodies

3.1.4 Disadvantages of Structured System Analysis and Design Method

1. Long development times as each stage must be completed thoroughly before moving on to the next
2. It costs time and money so organizations have to have large resources for SSADM projects
3. Lack of user involvement (i.e. the system rarely meets user needs and is less likely to be accepted) As it is sequential and not iterative, changes are not easily implemented (i.e.it is not flexible)

Unified Process is based on the enlargement and refinement of a system through multiple iterations, with cyclic feedback and adaptation. The system is developed incrementally over time, iteration by iteration and thus this approach is also known as Iterative and Incremental software development. A unified process is a software development process that uses the UML (Unified Modeling Language) language to represent models of the software system to be developed. It is iterative, architecture centric, use case driven and risk confronting.

3.1.5Advantages of Unified Process

1. Allows for adaptive capability to deal with changing requirements throughout the development cycle, whether they be from customers or from within the project itself.
2. Emphasizes the need (and proper implementation of) accurate documentation
3. Diffuses potential integration headaches by forcing integration to occur throughout development, specifically within the construction phase where all other coding and development is taking place.

3.1.6Disadvantages of Unified Process

1. Heavily relies on proficient and expert team members, since assignment of activities to individual workers should produce tangible, pre-planned results in the form of artifacts.
2. Given the emphasis on integration, throughout the development process, this can also be detrimental during testing or other phases, where integrations are conflicting and getting in the way of other, more fundamental activities.
3. Arguably, unified process is a fairly complicated model. Given the assortment of the components involved, including best practices, phases, building blocks, milestone criteria, iteration, and workflows, often proper implementation and use of the unified process can be challenging for many organizations, particularly for smaller teams or projects.

Unified Process (UP) has been adopted in this work. Object Oriented Paradigm (OOP) is one of the styles of UP and has been adopted too. It has been used only at the level of requirement and analysis workflows.

OOP sees each essential component of the proposed System as an independent object. Hence, if one object fails, the entire system is not destroyed. Also, post-delivery maintenance is relatively easier and less costly. An object has both its attributes and methods all wrapped in a capsule. It also uses classes which are Abstract Data Types. Hence, both data security and abstraction are ensured. OOP also ensures that what is desired is what is constructed.

3.2 System Analysis

3.2.1Data Gathering Technique

Information gathering is about the methods that are used to collect information from a sample group in a systematic way. The choice of which methods to use is influenced by costs, coverage of the target population, flexibility of asking question, respondents' willingness to participate and response accuracy. Interview, online survey, study of system, facilitated questionnaires, brainstorming among others are methods of information gathering. To achieve the project work, I used interview, internet brainstorming, and study of related materials which are briefly explained below:

- Study of related material: I studied the documented materials on IOT based Comatose Patient Monitoring System from where I conceived how to go about the proposed system. This method is cheaper.
- Online surveys: internet was browsed for relevant information.
- Interview: I interviewed some staffs in various hospitals whose responses gave me more insight into the project work.
- Brainstorming: I also stormed my brain with others' which yielded some solutions thereafter.

3.2.2Analysis of Existing system

Among other reviews made, the comatose patient ward in FETHA 2 in Abakaliki has been reviewed and analyzed as stated below:

Currently in FETHA, the medical personnel on duty must have to check regularly on the coma patient to know if they have regained consciousness. This is quite stressful and at times creates emotional unrest. There is no way to confirm that patient is back from coma from a distance (say in his office).

Since the coma patient is unconscious, he does not have control over his body systems like the urinary system, etc. So, the medical assistant must have to stand by and regularly observe the patient and manage them.

The Nurses are appointed to take patient's readings on regular basis and should inform the duty doctor in case of emergency. The responsible doctor visits his patient one time in a day and nurse provides the noted readings.

The block diagram of the existing system is as illustrated below:

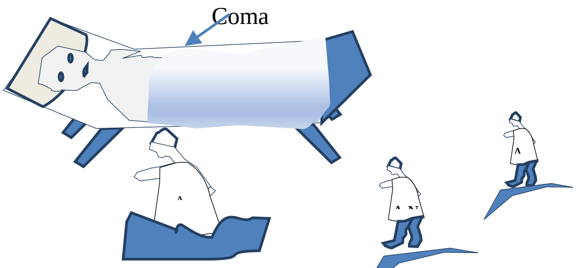


Fig. 4: The block diagram of the Existing system

3.2.3 Advantages of Existing System

The Existing system has the following advantages:

1. It creates job opportunities for the Nurses that keep an eye on the coma patient regularly.
2. The Nurses are able to manually take care of the coma patient.
3. It also creates opportunity for technological advancement.
4. The existing system does not include network challenge since it is purely manual.

3.2.4Disadvantages of the Existing System

The existing system has got some disadvantages which are stated below:

1. The existing system does not have a way of notifying the responsible doctor of the current health status of the coma patient.
2. The system is not able to monitor the coma patient's state in real time.
3. It is highly time wasting and inconveniencing to the nurses.
4. It does not take advantage of technological developments.
5. If the coma patient gains consciousness in the absence of the nurses, they might feel lonely for a while. This can be very discouraging.

3.2.5High Level Model of the Proposed System

The proposed system "Design and Construction of IOT Based Monitoring System for Comatose Patients has been analyzed using a block diagram and OOP

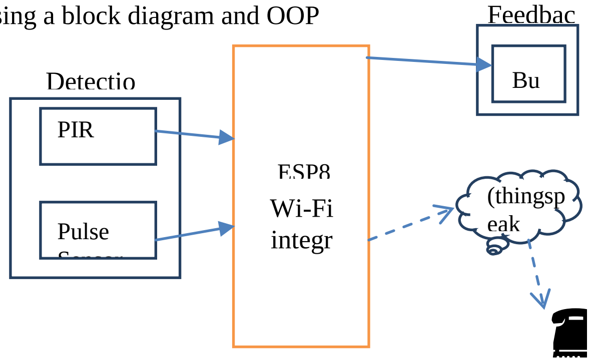


Fig. 5: The Block Diagram of the Proposed System

3.2.6Analysis of the Proposed System

Automated systems monitor the patient's parameters and when the doctor visits the patients, he just watches the parameters from the system's screen. So, there is a need for an IOT based system that monitors the patients for awareness. The system should be able to confirm (using some parameters) that the patient is awake and send IOT notification message to the responsible doctor in his office for necessary actions. This helps the doctors to give instructions to nurses at critical times like when they are away.

3.2.6.1 Functional Requirement

Requirements are statements that indicate what a system can do in order to provide a capability (i.e. utility or benefit.). requirements are generally prepared during the early stages of a project's system development lifecycle (SDLC.)

Types of requirements include functional requirement and non-functional requirement.

Functional Requirement

Functional requirement defines a system or its components. It describes the functions a software must perform. A function is nothing but inputs, its behavior, and outputs. It can be a calculation, data manipulation, business process, user

interaction, or any other specific functionality which defines what function a system is likely to perform. Functional software requirements help you to capture the intended behavior of the system. This behavior may be expressed as functions, services or tasks or which system is required to perform.
Use cases have been used to specify the functional requirements of the system. The use case of the entire system comes first, and then the various instances of the use cases followed.

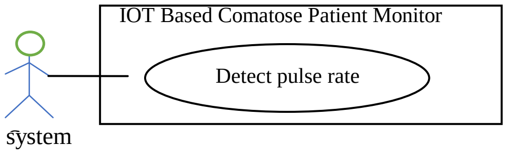
3.2.6.2 Use case diagram of the system
This diagram shows the interaction between the Smart System and the outside world. Here, the smart system and the user are actors.

.

This use case enables the system to monitor and detect body movement of the patient.

1. The system uses the PIR sensor to monitor the patient for any body movement.
2. If movement is detected, the system should raise alarm and send IOT notification to responsible doctor or nurses.
3. If no body movement is detected, the system should do nothing.

Fig 8:



This use case monitors the pulse rate of the Coma patients.

1. The system monitors the Coma patient for any rise or fall in pulse rate using the pulse sensor.
2. If the pulse rate rises above threshold, the system sends notification to the responsible doctor.
3. If the pulse rate is normal, the system does nothing

3.2.6.4 Non functional requirements
Non-functional requirement defines the quality attribute of a software system. They represent a set of standards used to judge the specific operation of a system. A non-functional requirement is essential to ensure the usability and effectiveness of the entire software system. Failing to meet non-functional requirements can result in systems that fail to satisfy user needs.
These are specifications that are not required for the system to work. But they are required to ensure and assure effective use of the system. They are as follows:

1. The system should be connected to steady power source.
2. The system should have steady network to ensure IOT notifications.
3. The system should be robust.
4. The system should work at least 99.5% of its time.
5. Startup time of about 15 seconds.

3.3 Object Model of the Proposed System
The System is conceived as a system made up of independent objects, which interact with one another to give the system its required functions. The following diagrams have been used to model the entire system in OOP.

3.3.1Class Diagram of the System
Class diagram shows the classes that make up the system. It also shows the composition and associative relationship among them.
From the class diagram, the system is into composition relationship with PIR sensor, Pulse sensor, Buzzer IOT classes. Also, it associates with Detection, Notification and Control Classes in various ways. Other classes also associate with each other differently. The class diagram is shown in below:

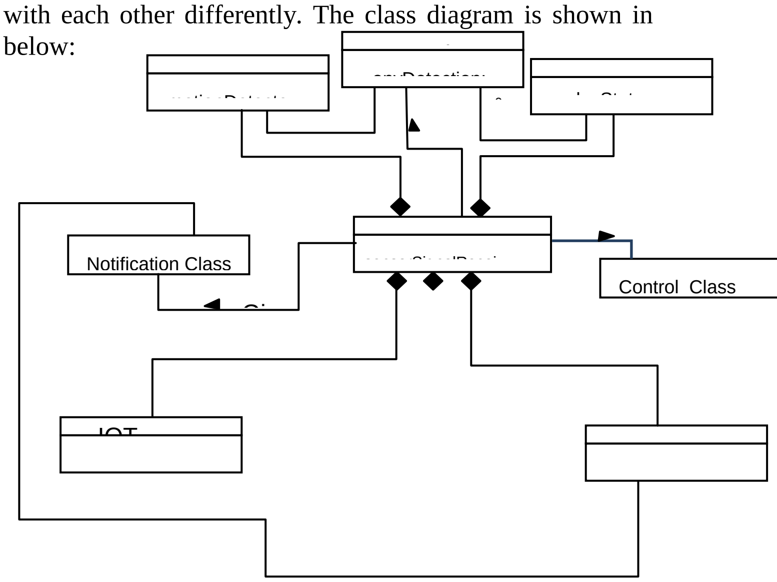


Fig. 9: The Class diagram for the System

3.3.2. The Communication Diagrams of the System
The communication diagram shows what classes of the system interact to produce overall results. We have considered the communication diagrams of two use cases: detect body motion and detect pulse rate as follows:.

3.3.3 Activity Diagrams for Use Cases
Detect body motion use case:

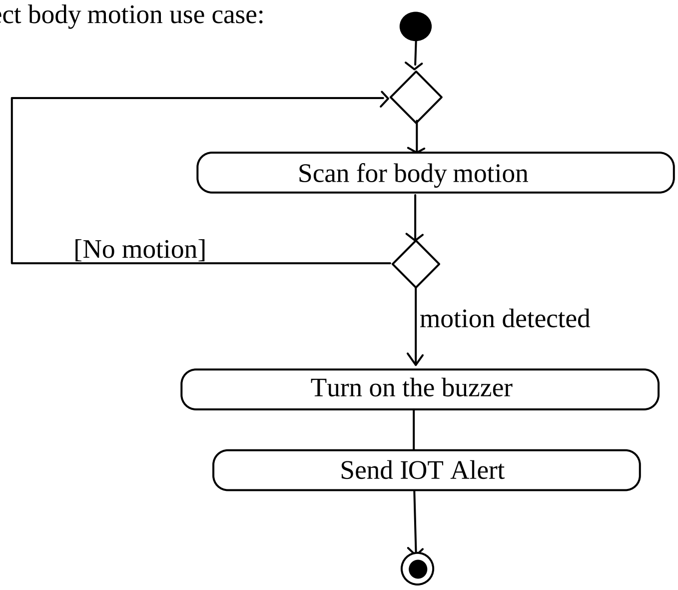


Fig. 12: Activity diagram to *detect body motion* use case

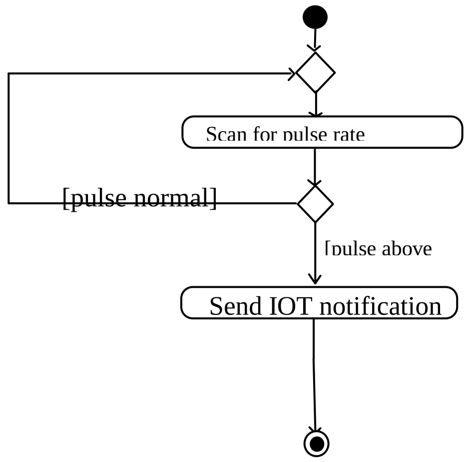


Fig. 13: Activity diagram to detect pulse rate use case

3.4: PART LIST

The components used in this work are as listed in table 8 below:

ITEM N0	DESC	QTY
1	ESP8266 Nodemcu 1.0	1
2	PIR Sensor	1
3	Pulse Sensor	1
4	Piezoelectric Buzzer	1
5	Breadboard	1
6	DC-DC Bulk Converter	1
7	Wiring and miscellaneous	1
9	9v battery	-
10	Labour	-

Table 2: List of component parts of the system

3.4.1Analysis of the Component Parts of the System

The system will be made up of three major sub units namely: detection unit, control unit and notification unit. These units are discussed below:

3.4.2 Control Unit

Esp8266 NodeMCU has been used as the main control and sequencing unit. It is an open-source Lua based firmware and **development board** specially targeted for IoT based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module.

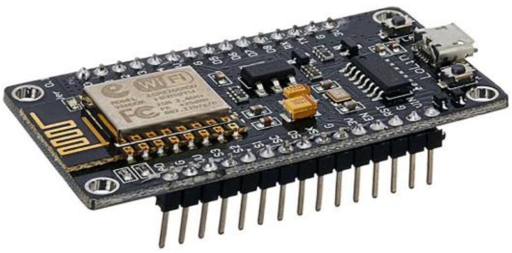


Fig.14: Esp8266 Nodemcu (https://components101.com/development-boards/nodemcu-esp8266-pinout-features-and-datasheet)

This microcontroller has been programmed to collect sensor data (motion, pulse rate), do all required analysis and computations and then triggers the corresponding output units.

Nodemcu has the following Features and Specifications:

Specification	Values
Microcontroller:	Tensilica 32-bit RISC CPU Xtensa LX106
Operating Voltage:	3.3V
Input Voltage:	7-12V
Digital I/O Pins (DIO):	16
Analog Input Pins (ADC):	1
UARTs:	1
SPIs:	1
I2Cs:	1
Flash Memory:	4 MB
SRAM:	64 KB
Clock Speed:	80 MHz

Table 3: Nodemcu Features and Specifications

3.4.3 Detection unit

This unit is responsible for detecting the body motion and also the pulse rate of the Coma patient. It then sends corresponding signal to the control unit for further analysis and computing. Two sensors make up this unit: PIR sensor and Pulse Sensor. They are both discussed below:

PIR sensor

The PIR sensor stands for Passive Infrared sensor. It is a low cost sensor which can detect the presence of Human beings or animals. This sensor has three output pins Vcc, Output and Ground as shown in the pin diagram above. Since the output pin is 3.3V TTL logic it can be used with any platforms like Arduino, Raspberry, PIC, ARM, 8051 etc.. The module can be powered from voltage 4.5V to 20V but, typically 5V is used. Once the module is powered allow the module to calibrate itself for few minutes, 2 minutes is a well settled time. Then observe the output on the output pin. Before we analyse the output we need to know that there are two operating modes in this sensor such as Repeatable(H) and Non- Repeatable(L) and mode. The Repeatable mode is the default mode.

The output of the sensor can be set by shorting any two pins on the left of the module as shown below. You can also notice two orange colour potentiometers that can be used to set the sensitivity and time which will be explained further below. This sensor has been used to detect body motion of the coma patient.

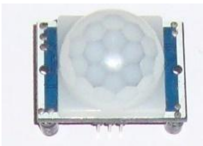


Fig.15: PIR sensor(https://components101.com/hc-sr501-pir-sensor)

PIR Sensor Specification

- Wide range on input voltage varying from 4.V to 12V (+5V recommended)
- Output voltage is High/Low (3.3V TTL)
- Can distinguish between object movement and human movement
- Has two operating modes - Repeatable(H) and Non-Repeatable(H)
- Cover distance of about 120° and 7 meters
- Low power consumption of 65mA
- Operating temperature from -20° to +80° Celsius

Table 4 Pin **Configuration of PIR Sensor**

Pin Number	Pin Name	Description
1	Vcc	Input voltage is +5V for typical applications. Can range from 4.5V- 12V
2	High/Low Ouput (Dout)	Digital pulse high (3.3V) when triggered (motion detected) digital low(0V) when idle(no motion detected
3	Ground	Connected to ground of circuit

1) 3.5 Pulse Sensor

The working of the **Pulse/Heart beat sensor** is very simple. The sensor has two sides, on one side the LED is placed along with an ambient light sensor and on the other side we have some circuitry. This circuitry is responsible for the amplification and noise cancellation work. The LED on the front side of the sensor is placed over a vein in our human body. This can either be your Finger tip or you ear tips, but it should be placed directly on top of a vein.

Now the LED emits light which will fall on the vein directly. The veins will have blood flow inside them only when the heart is pumping, so if we monitor the flow of blood we can monitor the heart beats as well. If the flow of blood is detected then the ambient light sensor will pick up more light since they will be reflected by the blood, this minor change in received light is analyzed over time to determine our heart beats.

The pulse sensor is used in this project to monitor the patients' heart or pulse rate by placing it on their finger tips or ear tips.

Fig. 16: The pulse sensor pin out (https://components101.com/sensors/pulse-sensor)

3.11 Features of Pulse Sensor

- Biometric Pulse Rate or Heart Rate detecting sensor
- Plug and Play type sensor
- Operating Voltage: +5V or +3.3V
- Current Consumption: 4mA
- Inbuilt Amplification and Noise cancellation circuit.
- Diameter: 0.625"
- Thickness: 0.125" Thick

2) Table 5: Pin Configuration of Pulse Sensor
3)

Pin Number	Pin Name	Wire Colour	Description
1	Ground	Black	Connected to the ground of the system
2	Vcc	Red	Connect to +5V or +3.3V supply voltage
3	Signal	Purple	Pulsating output signal.

The output unit:
This unit can also be called the actuators. They are used by the system to either give feedback or control real life situations. The buzzer has been used as the output unit. It has been discussed as below:

The buzzer:
The buzzer is used in the research work to locally raise an alarm once the coma patient gains consciousness and makes body movement. It has two wires: red (+5v) and black (0v).

Figure 17: Active buzzer (https://hub360.com.ng/product/buzzer-3v-24v/)

The Specification of Active buzzer is as below:

Colour:	Black, white
Alarm Diameter:	22mm/0.86″
Alarm Height:	10mm/0.39"
2 Mounting Holes distance:	30mm/1.18″
2 Wires length:	90mm/3.54″
Buzzer Type:	Piezoelectric
Sound Pressure Level 95	Db
Rate Voltage:	12V DC
Operating Voltage:	3 – 24V
Max Current Rating	10mA
Frequency	3900±500Hz
Drive Method:	Drive Circuit Built in Mounting Holes
Sound:	" Di" Continuous

Table 6: Specification of Active buzzer

3.6 Blynk IOT Platform

(https://iotbyhvm.ooo/blynk-tutorials-blynk-iot-platform-how-to-use-blynk/)

Blynk was designed for the Internet of Things. It is most popular IoT Platform. It can control hardware remotely, it can display sensor data, it can store data, visualize it and do many other things. With Blynk Library you can connect **over 400 hardware models** (including ESP8266, ESP32, NodeMCU, all Arduinos, Raspberry Pi, Particle, Texas Instruments, etc.) to the Blynk Cloud.

There are three major components in the platform:

- **Blynk App** – allows one to create amazing interfaces for projects using various widgets.
- **Blynk Server** – responsible for all the communications between the smartphone and hardware. One can use BlynkCloud or run one's private Blynk server locally. It's open-source, could easily handle thousands of devices and can even be launched on a Raspberry Pi.
- **Blynk Libraries** – for all the popular hardware platforms – enable communication with the server and process all the incoming and outcoming commands.

Now imagine: every time you press a Button in the Blynk app, the message travels to space the BlynkCloud, where it magically finds its way to your hardware. It works the same in the opposite direction and everything happens in a blynk of an eye.

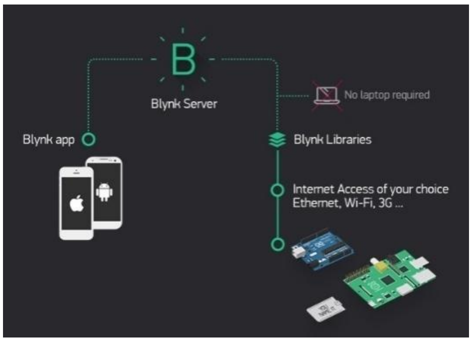


Fig.18: How blynk works

IV. SYSTEM DESIGN AND IMPLEMENTATION

4.1 The proposed system assembly

Figure 1 below shows inner assembly of the proposed system. It shows how the Pulse Sensor, Passive Infrared Sensor (PIR), buzzer, the power circuit and ESP8266 Nodemcu microcontroller are all assembled together for the comatose monitoring system and user notification.

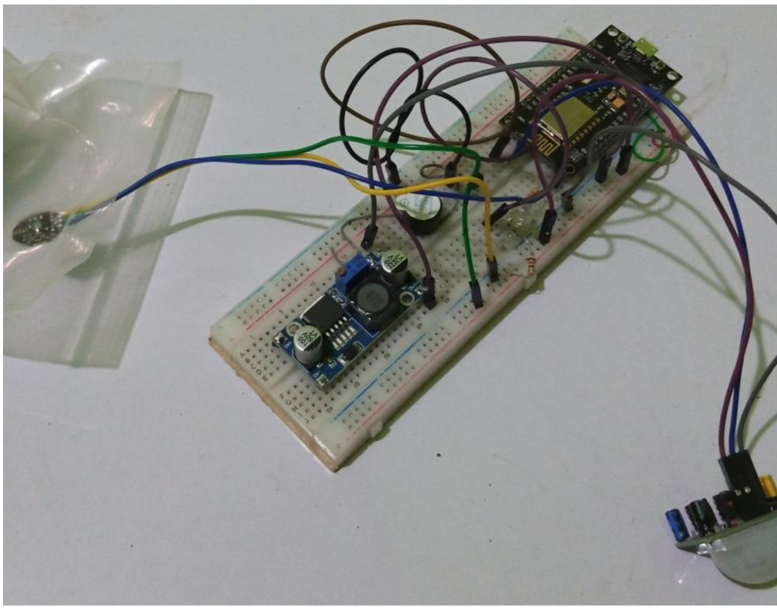


Fig. 19: Proposed system physical assembly.

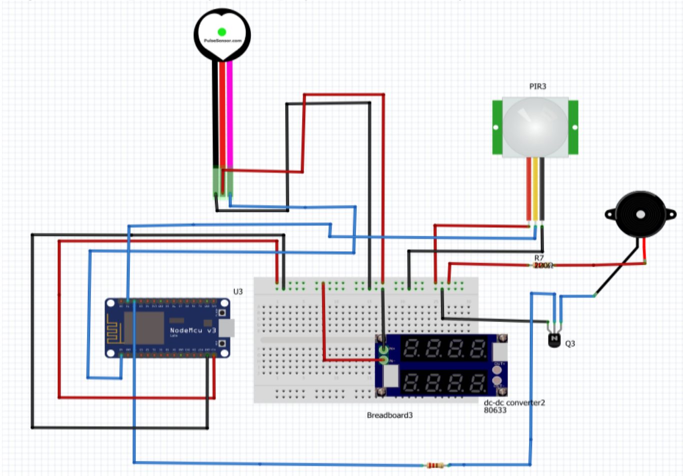


Fig. 20: System breadboard view

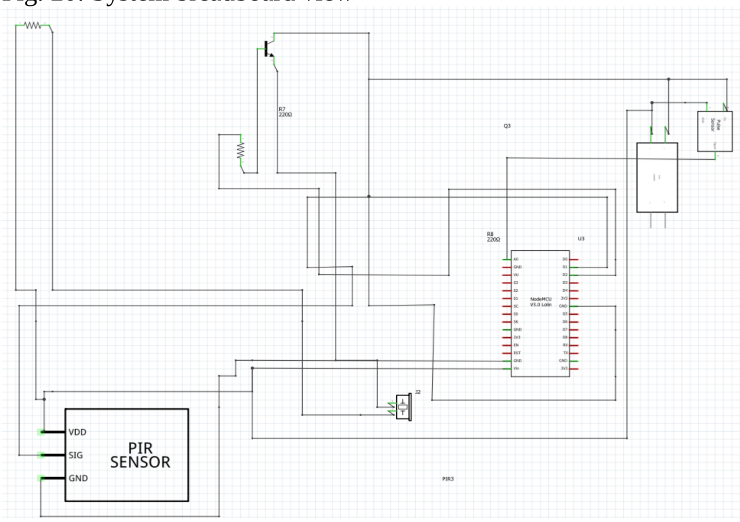


Fig. 21**:** System Schematic View

The Nodemcu is the main controller of the entire system. It has several digital input/output pins and power pins. It has only one analogue pin, which is for connecting analog sensors. In this project, the Nodemcu is powered by the +5v sourced from the power circuit.

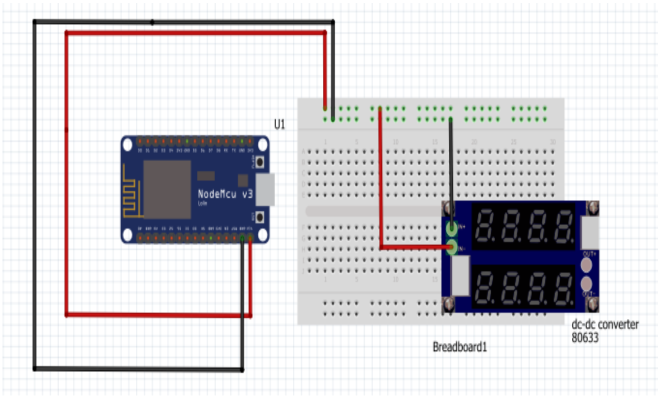


Fig.22 : Nodemcu interfacing with LM2596 DC-DC converter.

The power circuit is made up of 9v battery and LM2596 DC-DC bulk converter. The converter is able to take up to 30v from any dc power source. It has an onboard potentiometer for varying the output voltage in order to suit the user's voltage need. So 9v battery has been used as input to the converter and the required output is 5v which is now safely used to power the microcontroller for its operations.

The microcontroller is connected to the computer for programming through a 5v usb cable. Once the connection is made, the Microcontroller circuit will be detected by the computer and the actual port is selected by the programmer for programming operations.

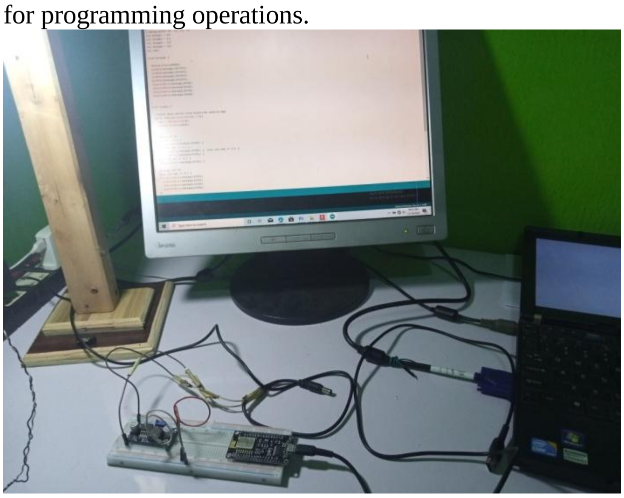


Fig. 23: Microcontroller programming with usb cable and laptop

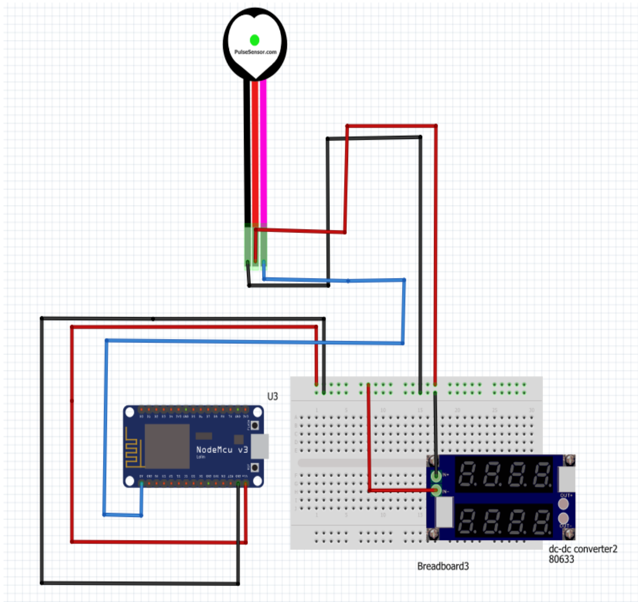


Fig.24: Pulse sensor interfacing with the microcontroller.

The Pulse sensor is responsible for detecting the pulse rate of the comatose patient. It has three connection pins: VCC, GND, A0. The VCC pin is connected to the +5v rail while the GND pin is connected to the 0v rail. Then the A0 pin has been connected to the pin A0 of the Nodemcu for digital signal transfer.

The PIR sensor is responsible for detecting the motion of the comatose patient. It has three pins : the VCC, GND and OUT. The VCC and GND pins are connected to the power and ground rails respectively. The OUT pin is connected to the pin D1 of the Nodemcu for motion signal transfer.

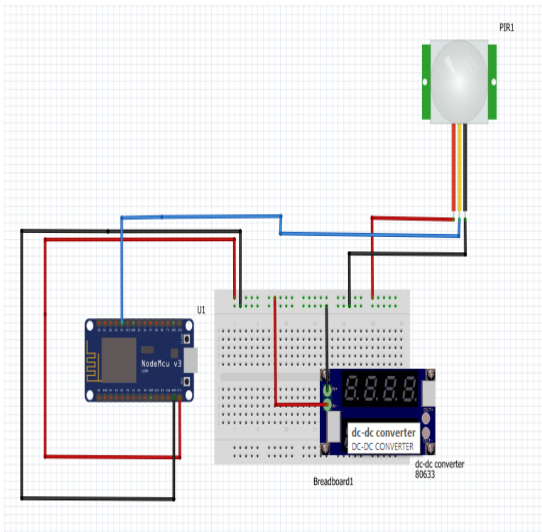


Fig. 25: PIR interfacing with the microcontroller

The Buzzer is used for alarm purposes. It is triggered once the PIR sensor body movement from the comatose patient. It has two pins: VCC and GND. The buzzer has voltage which is higher than the Controller requires. Hence, its Positive pin is connected to the base a 2n2222 NPN transistor which functions as a switch. The base of the transistor is then connected to the pin D2 of the controller. The GND of the buzzer is connected to the ground rail.

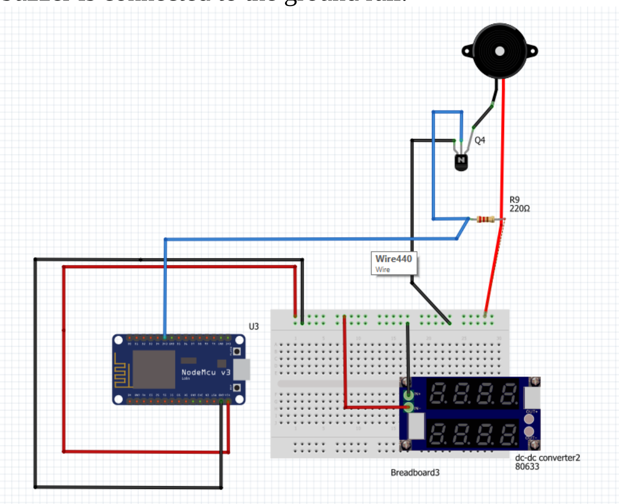


Fig.26: Buzzer interfacing with the microcontroller

4.2 Design software for the system

Fritzen software has been used for the schematic designs above. This software provides models for most of the components used in tech designs. It was used to model the interfacing of various component parts of the System. It provided us with components like Nodemcu, PIR Sensor, Pulse sensor, Buzzer, jumper cables, etc.

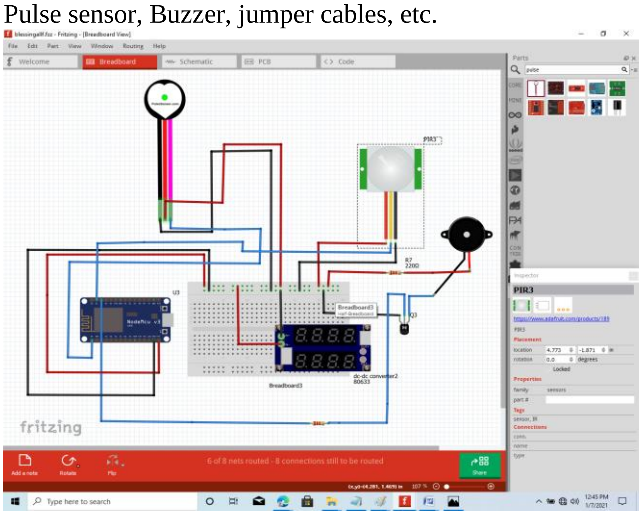


Fig 27: Fritzen software

The Procedure is listed below:

- Load the Fritzen Application.
- You can choose Breadboard, Schematic, PCB, or Code tab depending on what you want to do. Breadboard has been selected as we need to interface components only.
- Search for and pick any component models you want from the Part panel by the right of the window. This is done by dragging it out to the workspace. You can position it anywhere on the workspace by dragging method.
- When all the required components have been gathered, you can begin to connect them together by dragging out a jumper wire from one component terminal to another component terminal. You can determine the color of the jumpers too.
- When you are done, you can save the overall model and export to any other application for use.

4.3 DATA ACQUISITION/DATABASE

The system uses two sensors to collect data from its surrounding environment for processing. The Pulse sensor collects the current pulse rate of the patient. This information is stored in the blynk App interface for a remote access by the medical personnel. The PIR sensor monitors the comatose patient for body movement. If movement is detected, it sends signal to the controller to trigger the buzzer for alarm. The controller uses its integrated wifi technology to connect to Blynk online store. From this cloud or online database, the doctor can view and monitor the health condition of the comatose patient. The proposed system is hosted on the Blynk server and its real time data can be accessed through the internet from anywhere in the world. He can also get notification to his email.

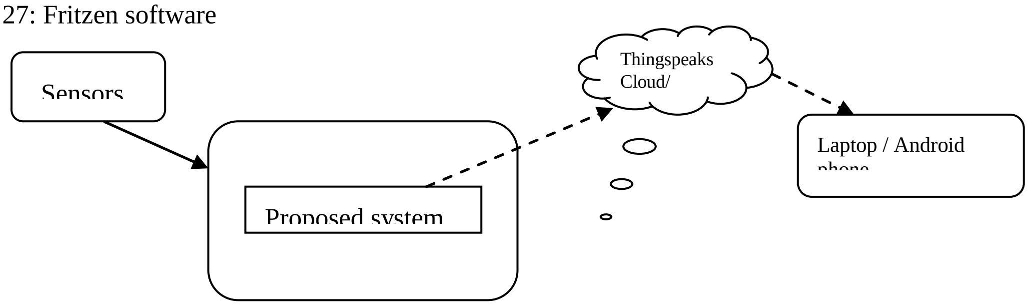


Fig.28: The data acquisition, storage and retrieving process

4.4 System Implementation Tool

The smart system was implemented using some software tools which are listed below:

1. Arduino IDE: making a sketch and programming the microcontroller
2. Micro C++: used as the main programming language.
3. Fritzen software: used for component interfacing

4.4.1 Arduino IDE

This is the development environment for the smart system code. This IDE enabled us to design a sketch (Write code) for the system. It also provides facilities for verifying (compiling) and uploading the code to the microcontroller for all control and sequencing functions.

The procedure is as follows:

1. Load Arduino IDE.
2. Create a new sketch and save it with a file name.
3. Design the sketch (write your control code).
4. Click on the verify button to compile the code. If errors were found, debug them and verify again.
5. Click on the upload button to upload (send) the sketch to the microcontroller. If there is port connection problem, debug it and try again.
6. Observe the system work according to your sketch.

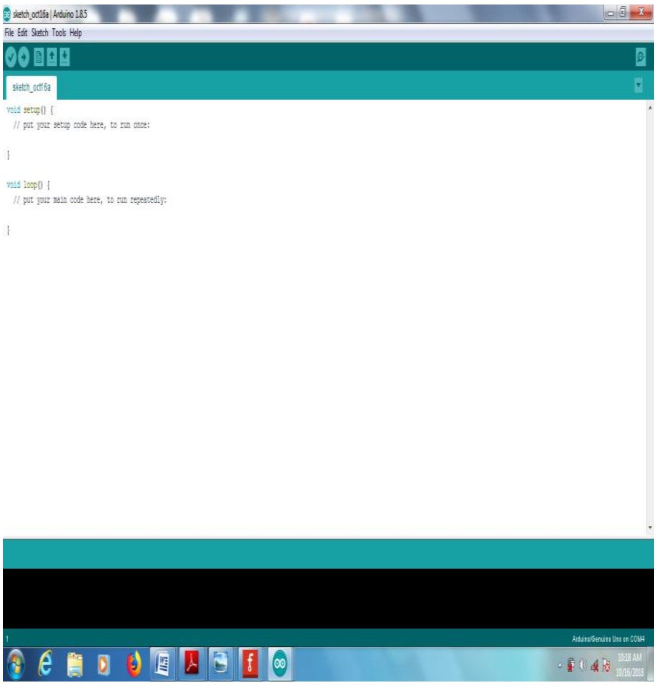


Fig. 29: Arduino IDE

4.4.2 C/C++ Programming

The implementation of this Smart system was done in C/C++ Programming language. The main component of the system that is programmed is the ATMEGA328P Microcontroller. The code (sketch) is written in C/C++, verified (Compiled) and finally uploaded to the chip for all control.

4.5 System usage

The system shall be used as stated below:

1. The user presses the ON switch on the system to power it.
2. The system boots for few seconds and all the sensors get activated.
3. The user must enable wifi network connection between the proposed system and his phone device. This is done by turning on his hotspot on the android phone and allowing the wifi network on the proposed system to connect. Once the connection has been made, there can now be signal transfer to the cloud for storage and retrieval online. The network coverage is just within the range of wifi.
4. Once the connection is created, the sensors (Pulse and PIR) begin to monitor the Patient for changes in their respective factors. These sensor data are immediately displayed on the blynk platform for users to access and view.
5. Apart from viewing the sensor data on the dashboard, the user can receive email notification should there be any inadequate pulse conditions.

4.6 System construction

The system was constructed using the following materials:

- A plastic casing with perforated holes for attaching the sensors and other components. It was also purchased from the market.
- Tools for perforation of holes: soldering iron and a stripper, a pencil and pen
- Hot gun glue for holding the components fast onto the casing.
- Screws and screw drivers.

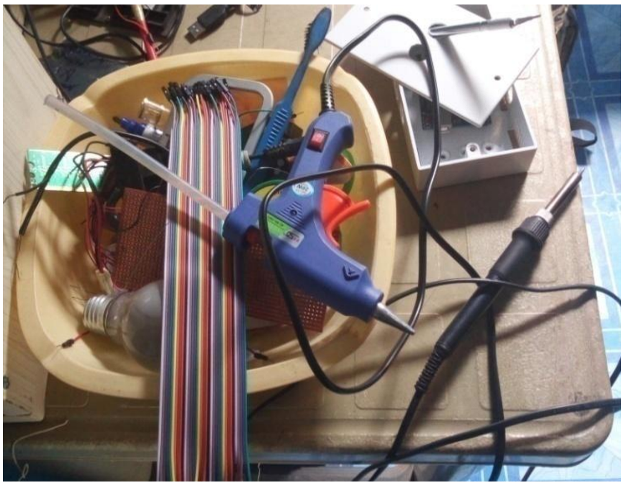


Fig 30: Construction Materials

4.7 System Testing

The Comatose Monitor was tested and the outcome is as discussed below:

4.7.1 Power on Test

The system was powered on by pressing the ON/OFF switch at the right side of the casing. Once the switch was pressed, the 9v battery in the casing supplied the required voltages to all the components of the system. A blue LED attached to the front of the casing blinked to indicate that the system was booting. It took about 2seconds for the system to power on.

4.8 Operational Test

The system was tested while in operation. After booting, the PIR and Pulse sensors were all activated. The user enabled wifi connection between the android phone and the smart system. After a successful wifi connection, the user logged in to the Blynk server and was able to view the current pulse rate of the patient. When the pulse rate was below or above threshold, the doctor was sent an email alert to his mobile device.

More so, the PIR sensor was able to detect the body movement of a comatose patient and the alarm blew.

All the above tests have been thoroughly summarized in table 11 below:

Table 7: Summary of the test carried out on the smart system

Event	Expected Action	Actual Action	Remark
The system was powered on	All components should receive specified input voltage to power on	All components were powered by 9v battery used.	Good

User enables inter-device wifi connections.	The smart system should connect to the phone's hotspot (access point) and the online interface should indicate that connection is made.	The connection was successful and the online interface indicated it. .	Good
The sensors send their current readings on the blynk platform and the user views them.	The Pulse and PIR sensors should send their current readings to the blynk display interface for the user to view.	The sensors sent their current readings to the interface and the user viewed them in order to take necessary actions.	Good
The doctor receives an email alert if motion is detected or pulse rate too high or too low.	The doctor should receive email alert if motion is detected or pulse rate too high or too low.	The doctor received email alert when the motion is detected or pulse rate too high or too low.	Good

The system was tested and all the expected results were equal to the actual results as seen in the table 7 above.

In every project work, it becomes inevitably important to give the overall achievement, limitation/drawback, and suggestions of further improvement. With this, one can understand the value of the project at a glance.

5.1 SUMMARY OF FINDINGS

The aim of this project was to "Design and Construct an IOT Based Comatose Patient Monitoring System" that is native; with the ability to indicate that a patient has regained consciousness and can display sensor data online in real time.

- The doctors can view the current readings of the sensors online in real time. This was achieved by using the thing speak cloud technology.
- This system is actually native. It is just made for clinics within our local areas.
- Again, it has the ability to ensure that the patients are in good conditions by checking and reporting their pulse rates.

5.2 CONCLUSION

The research work "Design and Construct an IOT Based Comatose Patient Monitoring System" has been finally completed, tested and confirmed to be working in line with Aim and Objectives stated earlier. However, it has got some limitations as listed below:

- The system does not have the ability to work offline. It is just Internet based.
- It uses local wifi network to connect to the internet. Any location that is not within the range of wifi will not access sensor information.
- In order to ensure affordability and reliability of the system, some of the sensors like temperature sensors, urine level sensors, air quality sensors, etc were not integrated.

5.3 RECOMMENDATIONS

- The system can be improved by integrating some sensor as listed in the limitations above to ensure an adequate environment for the comatose patients.
- The system can integrate more complex features like GSM (Global System for Mobile communication)/GPRS (General Packet Radio Service) Modules to enable communication with or without wifi local network.
- Other features can be added to make the system inform the user about its failure to detect external factors correctly.

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REFERENCES

[1] Shivleela Patil, Dr. Sanjay Pardeshi, Health Monitoring system using IoT International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 04 | Apr-2018 www.irjet.net p-ISSN: 2395-0072

[2] M. Sathya, S. Madhan , K. Jayanthi, Internet of things (IoT) based health monitoring system and challenges International Journal of Engineering &Technology, 7 (1.7) (2018) 175-178 International Journal of Engineering & Technology Website: www.sciencepubco.com/index.php/IJET Research paper

[3] Naveen Kansal, Hardeep Singh Dhillon, Advanced Coma Patient Monitoring System International Journal of Scientific & Engineering Research Volume 2, Issue 6, June-2011 1 ISSN 2229-5518 IJSER © 2011 http://www.ijser.org

[4] Fahad Ansari, Faizan Shaikh, Deepak Gupta, Touqueer Khan. Health Monitoring System Based on IoT, B.E. Dissertation Submitted in partial fulfillment of the requirement of University of Mumbai For the Degree of Bachelor of Engineering (Electronics and Telecommunication Engineering) Electronics and Telecommunication Engineering Anjuman-I-Islam's Kalsekar Technical Campus, Sector 16, New Panvel, Navi Mumbai (Affiliated to University of Mumbai) 2016-2017

[5] Israt Jarin Hoque, Md.Shadman Navid, Rifat Binte Reza, Mashwab Ibna Mahbub. IoT BASED PATIENT MONITORING SYSTEM Department of Computer Science and Engineering (BRAC University) SUBMISSION DATE: 25.03.2018

[6] K. Narendra Swaroop , Kavitha Chandu , Ramesh Gorrepotu , Subimal Deb, A health monitoring system for vital signs using IoT. Internet of Things 5 (2019) 116–129 Contents lists available at ScienceDirect Internet of Things journal homepage: www.elsevier.com/locate/iot Open Software and Data .

[7] Isaac Machorro-Cano, Giner Alor-Hernández , Mario Andrés Paredes-Valverde, Uriel Ramos-Deonati, José Luis Sánchez-Cervantes and Lisbeth Rodríguez-Mazahua (PIS IoT: A Machine Learning and IoT-Based Smart Health Platform for Overweight and Obesity Control 2019)

[8] C.-R. Su, J. Hajiyev and C.J. Fu et al. A novel framework for a remote patient monitoring (RPM) system with abnormality detection / Health Policy and Technology 8 (2019) 157–170. Contents lists available at ScienceDirect Health Policy and Technology journal homepage: www.elsevier.com/locate/hlpt

[9] K. Krishna Ganesh, H.R. Ranjan, a project report on patient monitoring system Department Of Bio-Medical Engineering GokarajuRangaraju Institute of Engineering and Technology (Affiliated to Jawaharlal Nehru Technological University) Hyderabad (2011) (abstract)

[10] **ALAN DENNIS** Indiana University, **BARBARA HALEY WIXOM** University of Virginia, **ROBERTA M. ROTH** University of Northern Iowa. SYSTEM ANALYSIS AND DESIGN **John Wiley & Sons, Inc.** http://www.wiley.com/college/dennis Fifth Edition 2012

[11] https://components101.com/development-boards/nodemcu-esp

8266-pinout-features-and-datasheethttps://components101.com/hc-sr501-pir-sensor
[12] https://components101.com/sensors/pulse-sensor

[13] https://hub360.com.ng/product/buzzer-3v-24v/

[14]https://iotbyhvm.ooo/blynk-tutorials-blynk-iot-platform-how-to-use-blynk/