IoT based real time low cost home quarantine patient aid system using blynk app

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Abstract. Recently, the world has been hit by COVID-19 pandemic. Nearly about every country has been devastated as they lack a proper health infrastructure. India is one such country where overpopulation is the key reason not everyone has access to medical facilities and are therefore forced to home quarantine. IoT is an ingenious technology which opens a new digitised path in terms of data storage and processing in today’s medical world to provide the healthcare systems with the best networking techniques. In this present paper, the authors have created a framework of body temperature, oxygen saturation level (SpO2), BPM (heart rate) and air quality sensors based innovative smart disease surveillance system with amalgamation of nodeMCU. The obtained output is displayed on the LCD display and additionally with the aid of IoT-cloud based app (blynk) the doctor can monitor real time health data. Also, a key feature named Report generates and sends the readings in CSV/Excel format. The health parameters of the proposed prototype have a maximum deviation of 1%, is cost-effective, portable, reliable and high functionality as compared to the commercially available one.

Keywords: IoT, nodeMCU, air quality, oxygen separation level (SpO2), LCD display, heart rate, body temperature sensor, cloud computing, blynk app

1. INTRODUCTION

The coronavirus or the COVID-19 is an infectious zoonotic disease which typically leads to Upper Respiratory Tract Infection (sinuses, nose and throat) (URTI) and Lower Respiratory Tract Infection (windpipe and lungs) (LRTI). COVID-19 is the disease caused by the SARS-CoV-2 virus. Its structure could be defined as spherical or pleomorphic enveloped particles consisting of single stranded (positive-sense) RNA related with a nucleoprotein with a capsid composed of matrix protein. The majority of human coronaviruses fall into one of two serotypes: OC43-like and 229E-like.
Coronaviruses invade the respiratory tract via two different cells which are found in the nose consisting of gene encoding protein. The COVID-19 pandemic has ever increased by numbers through the shortest span of time exponentially. The world is shook and annihilated by its devastating effects both economically as well as financially. Mankind can just hope for a cure (vaccine), but which may be a considerable time away. Till that day arrives, mankind must continue to fight against the virus with all its resources. It has presented a considerable threat for the clinical trial institutions for patient monitoring and treatment response.

The IoMT is that new emerging aspect of today’s technology that could provide a game-changing service to us. The IoT provides a well-defined and structured framework between computing and mechanical devices capable of transmitting enormous data effectively. It has the potential to serve mankind during the current pandemic on a large scale. The current situation of COVID-19 pandemic has emerged the need of a new solution in terms of a technology to serve the Medical Healthcare System effectively. IoT is just the perfect solution that the world currently needs. It is a revolutionary technology that is easily adaptable.[1],[2]

IoT is an ingenious technology to provide the healthcare systems with the best networking techniques. Rigorous processes such as data storing, tracking and retrieving information can be served effortlessly by the means of IoT. It opens a new digitised path in terms of data storage and processing in today’s medical world. Smart disease surveillance systems could be developed to record, analyse and predict trends on the current pandemic.[3],[4]

The practice of measurement of the body temperature of a patient is considered as a primordial and elemental in any healthcare constitution. It is a fundamental aspect to determine one’s medical condition and infer any possible judgement. LM-135 is used to read the patient’s body temperature with a high accuracy level interfaced with NodeMCU.[5]

The principle of spectrophotometry is applied to compute the ratio of oxygenated haemoglobin to deoxygenated haemoglobin which is further used to measure the % of oxygenated blood levels by the MAX30100 sensor. MAX30100 is encompassed with pulse oximeter and heart-rate sensor configuration is designed to request essential information of the wearable gadgets.[6],[7]

During this pandemic, the constant measurement of air quality plays a vital role in keeping one’s health condition steady. The air quality sensor module MQ-135 will serve an efficient aid to track the surrounding air quality and cautions if any hazardous gas is detected.[8],[9],[10]

The sensor-implanted system is based on Arduino which is aimed to track blood saturation level (SpO2), body temperature, and heart-rate simultaneously and digitally displayed on an LCD. This is an efficient manner to monitor and analyze the healthcare data.[11],[12],[13]

1.1. Motivation

The COVID-19 pandemic has been relentless on mankind since its outbreak. As it burgeoned, hospitals and healthcare centres flooded with patients in no time. As these facilities began only to be served to the needy and rich, a method was required to succour the rest. Our device is just the apropos to the problem. It is handy, cheap, highly efficient and indeed the perfect choice for the home-quarantined people.

Keeping this view factor, the researchers’ anatomy has noticed after referring literature review that many of past papers are based on the Arduino platform on an individual basis. Very few researchers have intended to combine various sensors on a single platform. As of the current prevailing conditions, authors in current research have endeavoured to innovate a healthcare system to measure heartbeat, blood oxygen level (SpO2), temperature and surrounding air quality of a patient which are collected through various sensors with nodeMCU. This resultant data is stored on a cloud-based system and will be sent to the doctor via the blynk app to monitor a patient's real-time health conditions. It is equipped with highly effective and accurate sensors inspired by being cost effective. This proposed model is a perfect, portable and cheaper alternative to those available in professional workplaces.
2. Methodology

![Figure 1. Home Quarantine Monitoring System]

2.1. LCD along with I2C module

The LCD (Liquid Crystal Display) with I2C module is an external device to produce an output onto a screen. One of its basic primary types is the 16X2 LCD display which is the most commonly used amongst beginners in their project. LCD’s are preferred by all as they are inexpensive, easy to use and available everywhere. Using the I2C module attached to LCD helps us in using it nodeMCU, as it only requires 4 pins for connection instead of 16 pins. This prototype includes an LCD module to display the body temperature, SpO2 and BPM.

![Figure 2. LCD Display]

2.2. Heart Rate and Blood Oxygen Level [SpO2] (MAX-30100)

Heart rate is also a beneficial indicator of the physiological adaptation of the human body and its intensity of effort. It provides an object measurement of how capable your body is to perform a strenuous activity.

Mechanism of action of heart rate in (COVID-19): The virus can damage muscle functioning, so monitoring heart rhythm to analyse cardiac arrhythmic condition, bradycardia, tachycardia of the patient’s heart.

The amount of oxygen flowing in the blood is known as the blood oxygen level. It is an important measurement in medical aspects as it indicates the oxygen concentration in blood available for each cell in the body. The effectiveness of how appropriately the body disperses oxygen from the lungs to the cells, which is cardinal for an individual’s health.

Mechanism of action of SpO2 in (COVID-19): As the virus enters the lungs, it starts to produce numerous cytokine storms which causes lung failure. Thus, the lungs are unable to infuse blood with oxygen which is vital for energy in multiple cells and organs.
Table 1: General Symptoms Heart-Rate and SpO2

MAX30100 is a unified solution of heart-rate and blood oxygen level sensor (SpO2). It comprises of a photodetector (Red), two LED’s (IR and Red), optimized optics and low noise analog signal processing to detect heart-rate signals and pulse via an oximeter. It finds its application in fitness assistance, wearable and medical monitoring devices. The authors have used a MAX-30100 sensor to sense the saturated oxygen in the blood along with heart beats per minute of the patient.

Figure 3. MAX-30100

2.3. Body temperature (LM-35)

Because of COVID-19, workplace temperature testing is becoming recurrent, as the body temperature is a significant and crucial sign of one’s medical state. It is one of the four main essential signs that must be monitored to ensure a safe and sound healthy condition. The mean body temperature is 98.6°F (37°C) as measured by mouth.

Table 2: General Body Temperature Range

LM-35 is an IC temperature sensor that has a temperature range between -55°C to 150°C. It outputs an analog signal which varies linearly with temperature. It has a high accuracy level in terms of measuring humidity and temperature levels. It can be operated from 4V to 30V. It can be easily set-up and interfaced with Arduino to output temperature readings. LM35 is used to read the patient’s body temperature.

Figure 4. LM-35
2.4. MQ-135

The MQ-135 is a gas sensor, primarily finding its application in air-quality measurement devices is capable of detecting gases such as NH3, CO2, smoke, Alcohol etc. Its fast responsiveness, high sensitivity and low cost makes it one of the most commonly used devices for air-quality measuring devices. It is a symmetrical 6-terminal device with sensors having an operating voltage of 5V.

The MQ-135 sensor might not look important but it’s one of the important sensors. Since a person is home isolated in a room, and there are chances that there might not be any air circulation and a lot of the bad air gets trapped in the room and can increase the pressure/load on the lungs of the patient and make his condition worse. When the quality of the air gets bad in the room the authors have added an led which turns on letting the patient in the room know that air in the room is not good for him, also there is a gauge in the doctor’s app which lets him/her know that the air quality of the patient’s room is not good and advises the patient accordingly.

![Figure 5. MQ-135](image)

2.5. NodeMCU

NodeMCU is an open source platform for IOT development. It includes firmware which is necessary to run ESP8266 and hardware which are based on ESP-12 module. Some of its advantages relative to Arduino are low cost, reduced physical size, lower energy consumption and integrated support for Wi-Fi networks.

Both its firmware and prototyping board designs are open source. The Lua scripting language is used for scripting. It is also programmed using an Arduino IDE. NodeMCU is the brain of our system, all the sensors are connected to the nodeMCU and the data received from various sensors are computed, analysed, display the SpO2 and BPM on LCD and then send all the data to the cloud. So authorized person i.e. doctor could read the vitals readings.

![Figure 6. NodeMCU](image)

3. Proposed System

The authors’ aim is to design a framework with a proposed hi-tech sensor fetching patient’s health data such as heart-rate, SpO2, surrounding air quality and body temperature amalgamated with nodeMCU. A well-established system is formulated using all the components mentioned above. There is also a necessity to connect passive units externally to the nodeMCU as the sensors can’t be directly associated with nodeMCU. It consistently updates the data to doctors using an IoT-cloud based system. It cautions the concerned by alerting them if the data goes out of the range to prevent any fatal incidents. This configuration was tested among 25 volunteers from various age groups in a locality. On the analogy between this system and the commercially available one to measure heart-rate, blood level (SpO2), and body temperature has been performed. The results were superlative in the favour of this system which not only a simple, handy and a cost-effective model, but also provided compendious information instantly. This system is for every unattended and solitary person who is quarantined in need of medical assistance.
The readings are collected by various sensors and the data is sent via the blynk app every two hours (every one minute), through which the concerned doctor consistently monitors the reading of the home quarantine patient. In addition, there is even an option which the authors have added in the blynk app known as Reports which emails the readings of the patient in CSV or Excel format to the Doctor on a daily basis. The doctor also gets an alert notification if the patient’s condition gets worse.

3.1. Circuit Diagram

![Circuit Diagram](image)

**Figure 7.** Circuit Diagram of Proposed System

3.2. Flow Chart

![Flow Chart](image)

**Figure 8.** Program Flow Chart
4. Result and Discussion

In the below tables, various parameters of the patient’s medical data are recorded every one minute and sent via Blynk app to the doctor. These include SpO2, heart-rate, body temperature and air quality of room which are sent in excel CSV format with the aid of Report feature. The doctor also gets notified by alert notification if the patient’s condition gets worse. The authors in current had examined twenty patients of which details of three are given below.

| Time          | SpO2 (%) | Heart Beat (BPM) | Body Temperature (°C) | Room air quality |
|---------------|----------|------------------|-----------------------|------------------|
| 12:00:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:01:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:02:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:03:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:04:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:05:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:06:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:07:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:08:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:09:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:10:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:11:00 AM   | 95       | 63               | 36.22                 | 0                |

Table. 3 Medical Data of Patient 1

| Time          | SpO2 (%) | Heart Beat (BPM) | Body Temperature (°C) | Room air quality |
|---------------|----------|------------------|-----------------------|------------------|
| 12:00:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:01:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:02:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:03:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:04:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:05:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:06:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:07:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:08:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:09:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:10:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:11:00 AM   | 95       | 63               | 36.22                 | 0                |

Figure 9. Graphical Medical Data (Patient 1)

| Time          | SpO2 (%) | Heart Beat (BPM) | Body Temperature (°C) | Room air quality |
|---------------|----------|------------------|-----------------------|------------------|
| 12:00:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:01:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:02:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:03:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:04:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:05:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:06:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:07:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:08:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:09:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:10:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:11:00 AM   | 95       | 63               | 36.22                 | 0                |

Table. 4 Medical Data of Patient 2

Figure 10. Graphical Medical Data (Patient 2)

| Time          | SpO2 (%) | Heart Beat (BPM) | Body Temperature (°C) | Room air quality |
|---------------|----------|------------------|-----------------------|------------------|
| 12:00:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:01:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:02:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:03:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:04:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:05:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:06:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:07:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:08:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:09:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:10:00 AM   | 95       | 63               | 36.22                 | 0                |
| 12:11:00 AM   | 95       | 63               | 36.22                 | 0                |

Table. 5 Medical Data of Patient 3

Figure 11. Graphical Medical Data (Patient 3)
5. Advantages of Proposed System

This device meets the following advantages as follows:

- It is a well-designed, user-friendly equipment used to measure data using sensors.
- It is highly accurate in terms of sensing information.
- The acquired information is constantly stored on the IoT-cloud based system.
- This information can be retrieved and sent as per choice.
- This system is remotely accessible, fast and secured.
- This method is also way cost-effective as compared to the traditional method of storing data as a hard copy.
- The doctor can analyse the patient’s conditions on a real-time basis and can give instructions accordingly.
- The doctor gets notified on worsening of the patient’s health condition and an ambulance can be sent to the required location.
- It minimizes the risk of exposure to the virus during this pandemic condition as it is crucial for healthcare resources and clinical providers.
- It can also find its application in day-to-day life activities such as sports, healthcare and other medical purposes.

6. Conclusion

This model/project is a small contribution in helping mankind deal with its current home quarantine situations. A simple, yet an innovative handy equipment armed with (all objects) affordable and accessible by all.

The current prototype deals with storage of data on the basis of cloud computing which includes a pulse oximeter to measure saturation point oxygen level (SpO2), air quality sensor and body temperature of a patient. It incorporates an idea of an IoT enabled heartbeat measuring system (BPM) comprising of a pulse sensor and a NodeMCU. It’s added features include an alert system cautions the doctor if the heart rate goes out of range preventing any fatal incident.

The prototype also proposes a framework of an app compatible with tablets and smartphones stores and analyses a patient’s medical record. This user-friendly app enables the patients to easily understand their data as well as conveying the relevant information to the doctor effectively. This proposed model conveys the idea of the perfect amalgamation of IoMT/IoT with the current healthcare system techniques.

A perfect portable and five times cheaper alternative to those available in professional workplaces. The health parameters of the proposed prototype have a maximum deviation of 1% as compared to the commercially available one.

### Table. 6 Validation Table

| Patient | Average SpO2 value by MAX-30100 (Author’s Prototype) | Average BPM value by MAX-30100 (Author’s Prototype) | Average Temperature value by LM-35 (Author’s Prototype) | Average Temperature value by Thermal Gun |
|---------|-------------------------------------------------------|----------------------------------------------------|-----------------------------------------------------|-----------------------------------------|
| PATIENT 1 | 95.250 | 66.187 | 36.460 | 36.590 |
| PATIENT 2 | 94.084 | 87.750 | 36.557 | 36.350 |
| PATIENT 3 | 95.334 | 58.000 | 37.507 | 37.250 |

Thus, it can be concluded that the author’s prototype is well-suited for measuring SpO2, BPM and the body temperature similar to that of a standard device with a deviation of nearly 1%. Therefore, it is a preferable, resourceful and cost-effective alternative of a standard device.
7. Future Scope

This prototype named "IoT based real time low cost home quarantine patient aid system using blynk app" the hardware part of the system configuration includes sensors such as the oximetry (SpO2), heart-rate, air quality sensor and the body temperature sensor along with the NodeMCU.

There is always room for innovation and novelty in any equipment. The world demands for a change as and when required as per new circumstances. This prototype can be modified in several ways in the future. Additional sensors such as ECG(Electrocardiography), EMG(Electromyography), Blood Pressure Sensor and SA9311M sensor for respiration sensing for multipurpose use of the prototype. It may be embedded with Active RFID (Radio-frequency identification), a revolutionary technology that records and reports a user's geographic location by the principle of radio waves. In regards to the situation of the COVID-19, it can be used to track the location of an infected person who is quarantined.

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