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ORIGINAL RESEARCH ARTICLE

Need of Li-Fi (light fidelity) technology for the world to track COVID-19 patients

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ABSTRACT

In this modern world, a single day without light or the internet is unimaginable. Nowadays, wireless fidelity, often known as Wi-Fi, is the most well-known and commonly utilized conventional wireless technology. Wi-Fi employs radio waves or electromagnetic waves to carry data across networks. Imagine if a basic LED light in and around the hospital could link us to high-speed wireless internet with just a simple flickering of light at a very high speed where eyes cannot detect it. This technology is known as Li-Fi, or light fidelity, and it is 10,000 times faster than Wi-Fi. Hospitals are among the locations where Wi-Fi is absolutely forbidden. As doctors are the frontline soldiers against COVID-19, the objective of this project is to develop smart healthcare systems that use green communications to monitor COVID-19 patients using temperature, pressure, and heart rate sensors from Li-Fi transmitter to Li-Fi receiver by using simple LED light as a medium to transmit the data or information of COVID-19 to the cloud by using Li-Fi Dongle.

Keywords: Wireless Sensors; Li-Fi Transmitter; Li-Fi Receiver; IOT; Wi-Fi; LED; Li-Fi Dongle; Photo Detector

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1. Introduction

COVID-19: an invited guest to stay longer than expected. Since approximately two years ago, the world has been talking about COVID-19, also known as the coronavirus. SARS-CoV-2 virus is the infectious agent that causes the coronavirus sickness. "The 72nd World Health Assembly designated September 17 as World Patient Safety Day to increase public awareness of the importance of health professionals and how they relate to patient safety. According to IMA COVID-19 statistics through September 16, a total of 2,238 doctors contracted the illness, and 382 of them died. This trend is ongoing[1]". Like India, no nation has lost as many as doctors and healthcare workers. In isolation ward having more than 1,000 or 2,000 beds, monitoring the COVID-19 patients is very essential. Monitoring the patient's temperature, heartbeat, pressure, and respiratory condition is very essential and should optimize to improve the COVID-19 patients survival. At present, in most of the hospital, monitoring the patients is done either manually or Wi-Fi[2]. Li-Fi provides advanced monitoring of where patients may access wireless data. It is vital to discover better solutions for every task in the age of rising technologies. Using Li-Fi technology, patient monitoring may be done quickly and efficiently. Wi-Fi-based patient monitoring is slower and has less bandwidth than Li-Fi-based patient monitoring. Because Wi-Fi transmits data through RF waves, these waves have the potential to harm humans. For a healthy environment, Li-Fi (light fidelity) technology is employed to overcome this problem[3].

This prototype consists of sensors such as temperature, heartbeat and pressure is designed to measure and monitor the temperature, pressure and heartbeat of a COVID-19 patient in order to accurately describe the status of her/his health and fitness. These sensors gather information from the human body, transform it to digital form via an analog to digital converter, and provide their outputs to a microcontroller. Sensors data displays on alphanumeric 16 × 2 LCD. The same data is transmitted to PC/Laptop through Li-Fi communication. Li-Fi transmitter is connected to microcontroller through UART interface. The Li-Fi transmitter analyzes and decodes the data communicates in 1 s and 0 s. Two microcontroller modules and a receiving circuit make up the receiver portion. The microcontroller transmits data using light, which a photo detector detects. The receiver model links to a receiver in the room that contains a Universal Asynchronous Receiver Transmitter (UART), and the values can be shown continuously. As a result, the patient can be observed 24/7, and their information can be easily updated.

1.1 Li-Fi (light fidelity)

"Li-Fi stands for light fidelity or visual light communication. Li-Fi is a wireless optical networking system that transmits data utilizing light from Light Emitting Diodes (LEDs) at frequencies between 400 and 800 terahertz (THz)[4]". Li-Fi technology is one of the sectors that is now being researched to improve the power of data transfer and inter-networking. Light fidelity is a type of data communication that employs visible light as a medium. LEDs improve efficiency, durability, and data throughput, allowing Li-Fi and Visible Light Communication (VLC) systems to expand. Li-Fi is known to be a light-based Wi-Fi that uses light to relay information instead of radio waves. Since its accidental development by Dr. Jhon O'Sullivan in 1992, Wi-Fi has revolutionized digital communication. Wi-Fi can account for 60% of all internet traffic, however, it does confront significant issues in today's world.

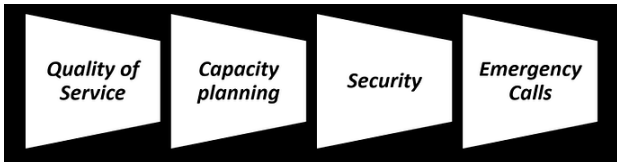

Figure 1. Issues with Wi-Fi.

Li-Fi is the ideal answer for these challenges in order to overcome them. Li-Fi is a better in hospital application for monitoring patient conditions since it does not interfere with the human body's frequency. A part of the suggested technology enables people to remotely upload or record crucial health symptom information for their doctor's assisted diagnosis during a pandemic, such as the ongoing COVID-19 sickness.

1.2 Need for Li-Fi

- Although there is a limited amount of radio spectrum, demand for cellular data is rising every year.
- Li-Fi resolves with the radio spectrum such as capacity, availability, effectiveness, and security.
- Data transfer speed can be enhanced.
- This technology has the ability to unlock the potential of IOT-driven industry 4.0 applications and pave the way for the emerging Light-as-a-Service (LaaS) lighting industry.

1.3 How does Li-Fi work?

By switching on and off a microchip-equipped LED thousands of times per second, it is possible to transfer information[4].

If it's on, it sends a 1 bit; if it's off, it sends a 0 hit. Because frequency shifts happen so quickly, they aren't apparent to the naked eye[4].

A light-sensitive receiver on the receiving device picks up the signal, which transforms it back to data[4].

The technology is capable of simultaneously sending thousands of data streams.

Because the light source must be turned on and off thousands of times per second, filament bulbs and fluorescent tubes are not suitable[4].

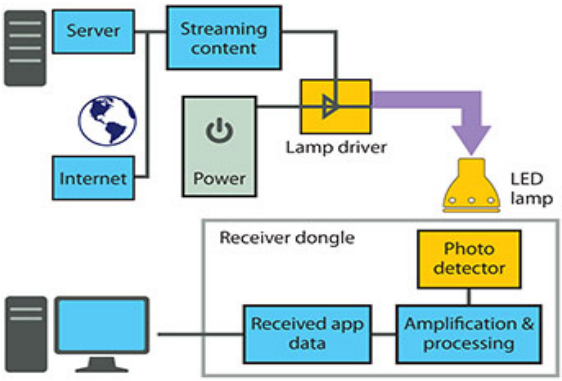

Figure 2. Architecture of Li-Fi (Image credit: Pure Li-Fi).

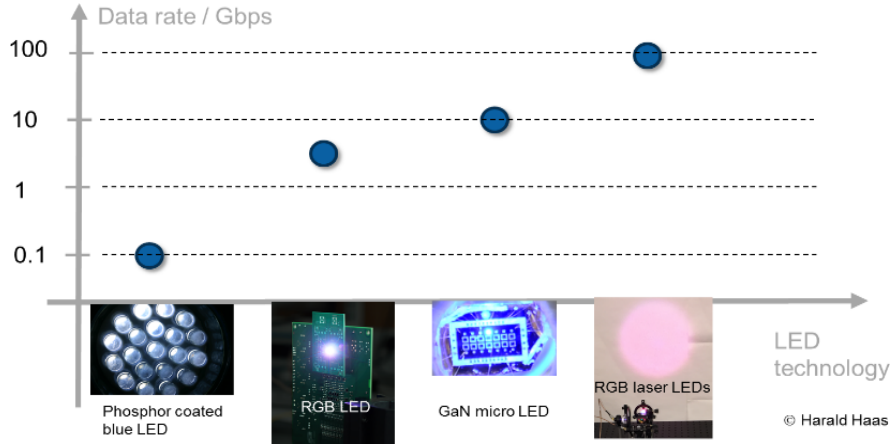

Figure 3. Data rate/Lighting technology[5].

2. Lighting technology

Up to 100 Gbps or higher can even be transmitted via Li-Fi, but this involves a transition in lighting technologies[5]. The phosphor coated white LEDs that are often used in all types of commercial lighting systems will give a maximum of 100 Mbps[5]. As shown in **Figure 3**, the more expensive Red, Green, Blue (RGB) LEDs may provide up to 5 Gbps and provide color customization[5]. White LEDs with a diffuser based on lasers can relay up to 100 Gbps and generate a broad light stream. On the fastest Wi-Fi with a frequency spectrum of 60 GHz, Wi Gig (wireless Gigabit) may attain a cumulative data throughput of 7 Gbps[5].

3. Objectives of the research

- To develop a safe, accurate and easy-to-use real time Li-Fi with IOT (Internet of Things) based COVID-19 patient monitoring system that can play a crucial role in the procurement of critical health services.
- To provide the continuous monitoring to the ICU COVID-19 patients or COVID-19 patients in Isolation ward using virtual media.
- To consult and advise COVID-19 patients using continuous monitoring media.
- To eliminate the need for a PC as a local database by a smartphone or laptop or iPad.
- To analyze and compute COVID-19 patients' health condition by an AVR microcontroller, Li-Fi and IOT, which is the heart of this research work.
- To collect temperature, blood pressure and heartbeat which are used to evaluate the health condition of the COVID-19 patient.
- To support the outdoor environment monitoring and tracking the location by a smartphone with GPS technology.
- To monitor the physiological parameters of COVID-19 patients from the doctor's desk using IOT and display the results using ThingSpeak website and thing view mobile app.
- To support security and access control, ThingSpeak API servers are used to support secure connections between devices and ThingSpeak.

4. Proposed methodology

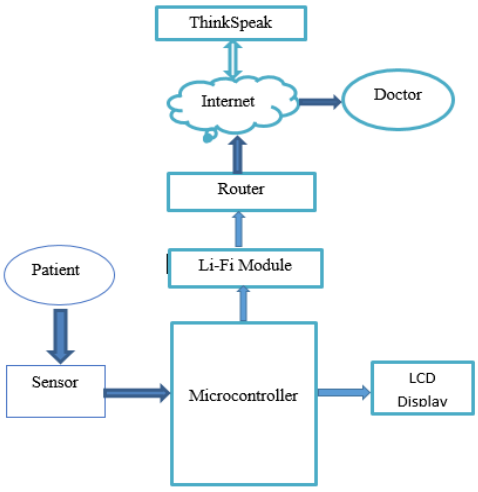

Figure 4. Flow diagram.

System block diagram: ICU patients' temperature, pressure, and heart rate are often monitored by sensors, computer analysis, or manually gathered data. As technology develops, they are now

completed via Wi-Fi. But Wi-Fi is not advised in the ICU. As a result, the environmentally benign technology known as Li-Fi has emerged, allowing several devices in a space to share data using light. Visible light communication (VLC) is the term for this. Visible light functions as a transmission channel in visible light communication (VLC). The use of Li-Fi in the biomedical area has expanded to include delivering the Electroencephalography (EEG) signal over VLC connection.

This prototype mainly consists of two units: Transmitter section and receiver section.

Transmitter section: Sensors, a PIC16F877A microcontroller, and a transmitting component make up this portion. We may employ transmitting components such as LEDs or lasers to achieve comparable outcomes, depending on our needs. We have used a LED for transmission, as well as a variety of other passive components.

Sensors: Here we have used three types of sensors.

Heartbeat sensor/pulse rate sensor: Patients' heart rate and blood oxygen levels are tracked by the heartbeat sensor using the photoplethysmography principle. It keeps track of any organ's change in blood volume, which causes that organ's change in light intensity, and generates an analog signal that is subsequently sent to a microcontroller.

Temperature sensor: The LM35 used here is a temperature sensor with a high level of accuracy. It features an analogue output that is proportional to the ambient temperature in a linear manner. To receive temperature measurements, just connect it to an ADC pin on your microcontroller.

Blood pressure sensor: Human blood pressure is measured using a non-invasive instrument called a blood pressure sensor. Systolic, diastolic, and mean arterial pressure are all measured using the oscillometric technique. Many people find it helpful to monitor their blood pressure at home, particularly those who have high blood pressure. Blood pressure fluctuates from time to time. It adjusts to what your body needs. Exercise, sleep, mental state, breathing, and body posture are all factors that affect it.

Microcontroller: PIC16F877A has been used here. The PIC 16FB77A microcontroller is recommended for this project to improve the model's functionality. We utilize the PIC 16FB77A, which has 40 pins, in our project. It is better to utilize because of its high efficiency and low power consumption. It is simple to connect all of the sensors to the microcontroller, which is programmed to analyze and communicate data in optical signals using the UART protocol, which is then conveyed using LEDs and LASERs. LED as a transmitting medium: because LEDs have a high switching capability,

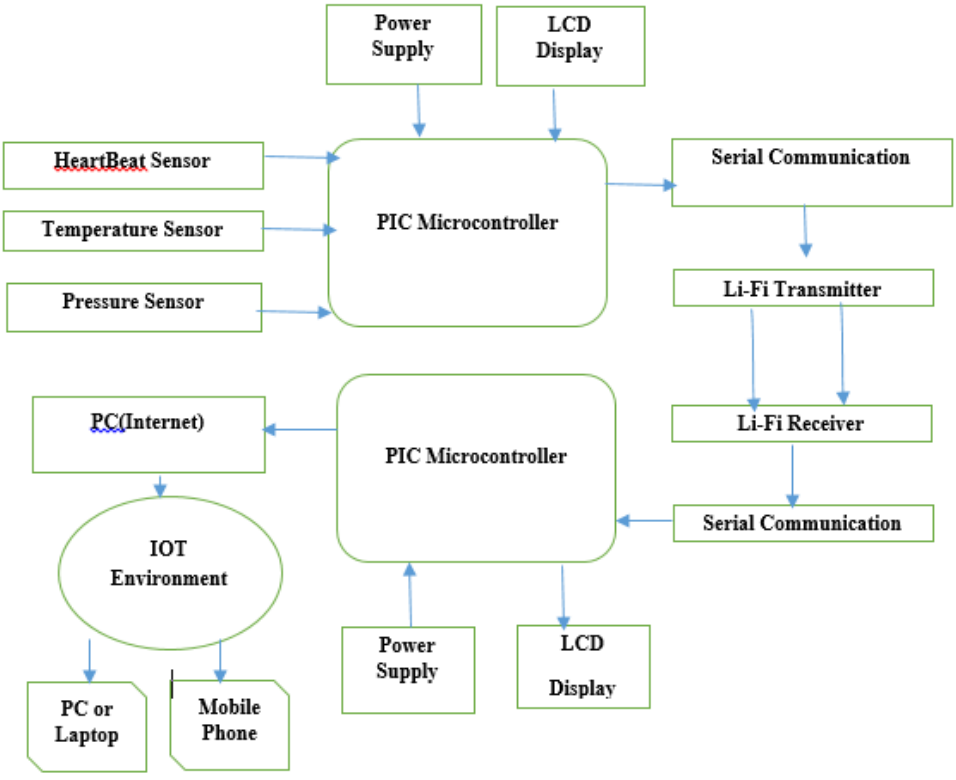

Figure 5. System block diagram.

they may be used to make high and low logic. In this case, we utilized an array of T1 34.5 mm LEDs, which have a high intensity and use a low current of 20 mA apiece. It also uses a lower voltage of 3.2 volts, allowing it to be utilized without a LED driver. We may also use a 650 nm 5 mW Focusable Dot laser Module Sensor instead of an LED to achieve more exact results.

Receiver section: The Li-Fi receiver processes the 1 s and 0 s, or LED ON/OFF states, before sending them across the UART interface to the PC or laptop. These bytes are received as python code, which will then be uploaded to a server. We utilize the ThingSpeak server's Application Program Interface (API) to submit the code. In ThingSpeak, sensor data is assigned to fields on the server and displayed as a graph. The API key for uploading data to the ThingSpeak server is generated automatically. Data from various sensors was communicated to ThingSpeak using Python scripting. Doctors may now obtain and view their results at any time and from any location by logging into a website. As a result, a Li-Fi-based COVID-19 patient monitoring system will play an important role in healthcare. To locate COVID-19–affected patients, a radiation-free equipment must be introduced in all hospitals.

5. Result

This section briefly summarizes the outcomes of the deployed COVID patient isolation and biomedical sensor data analysis systems. Thus, **Figure 6** shows the real-time display of pressure, temperature and heartbeat of the person. **Figure 7** shows the result of Python 2.7.10 shell to communicate data from different sensors to ThingSpeak and **Figure 8** shows the analysis and visual display of sensors data.

6. Advantages of using Li-Fi at hospital

The key benefits of Li-Fi at hospital are:

- Reduced cost. Healthcare professionals may use IOT systems and linked medical equipment to monitor patients in real-time. The overcoming of a radio frequency spectrum shortage (10,000 times more capacity).
- Enabling for extremely high peak data rates (10 Gbps).
- Li-Fi technology might theoretically be implemented for a low cost. It would be sufficient to include modulators in the lights and the requisite receivers in the devices.

7. Challenges of Li-Fi over Wi-Fi

Limited compatibility: Although Li-Fi is a relatively new technology, fewer devices are able to use it. It's unlikely that we will see Li-Fi-enabled personal electronics in the foreseeable future because the vast bulk of the technology we use today still relies on Wi-Fi networking gear[7].

Limited range: While the fact that light can-

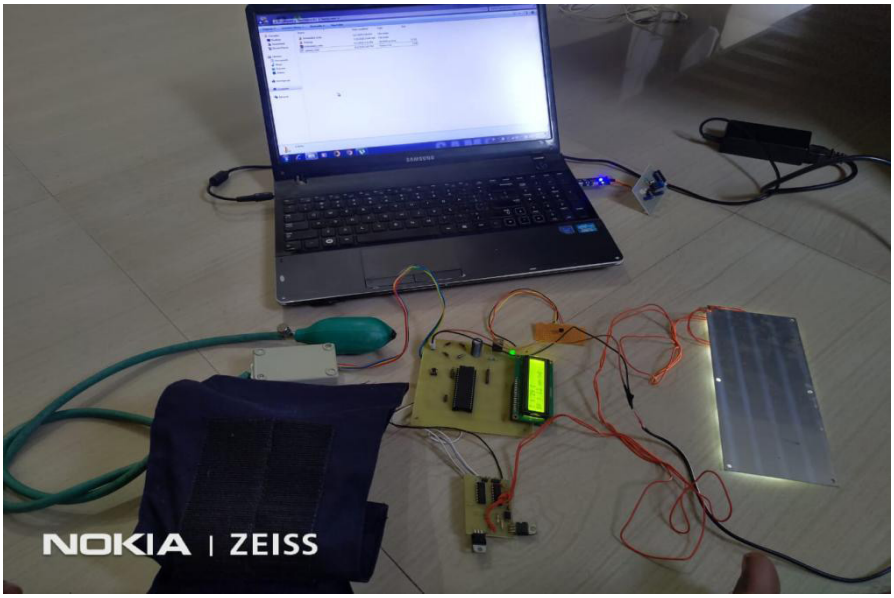

Figure 6. Prototype.

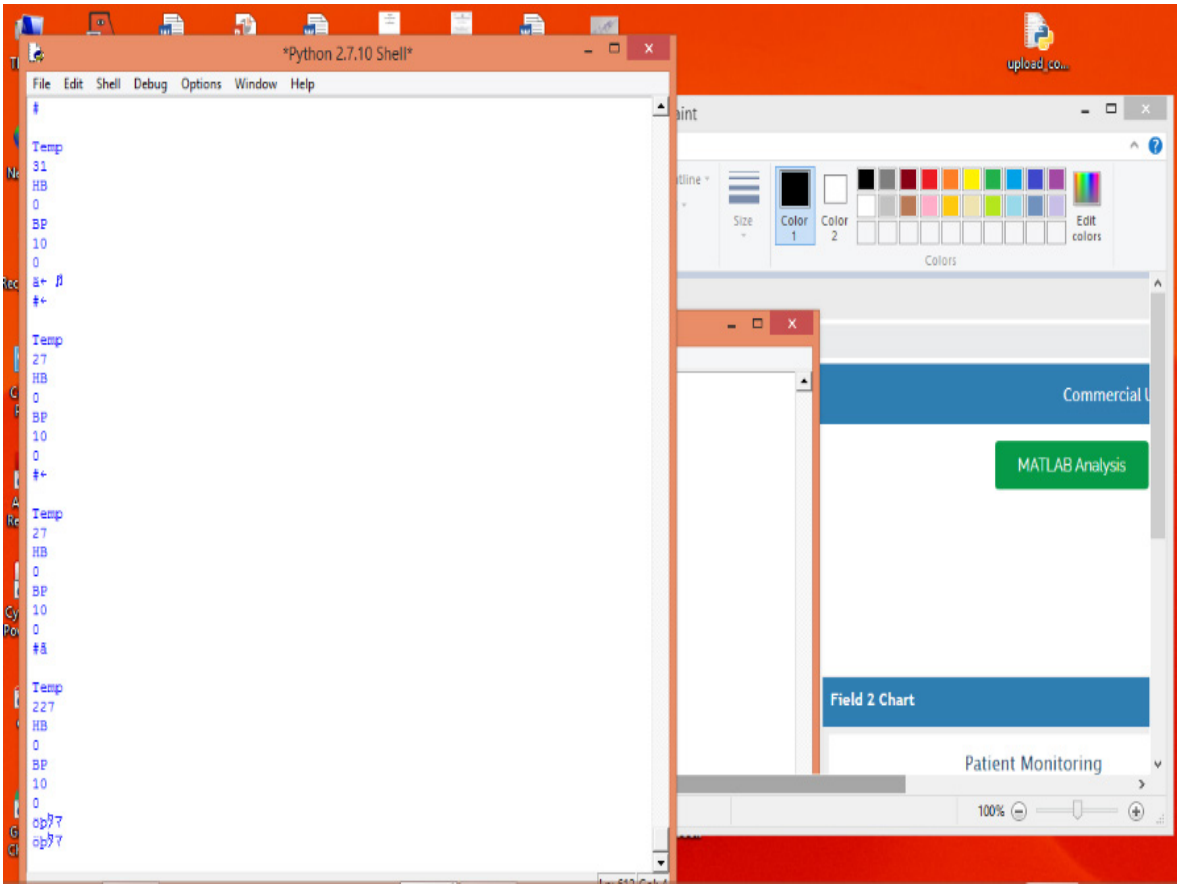

Figure 7. Python to communicate data from different sensors to ThingSpeak.

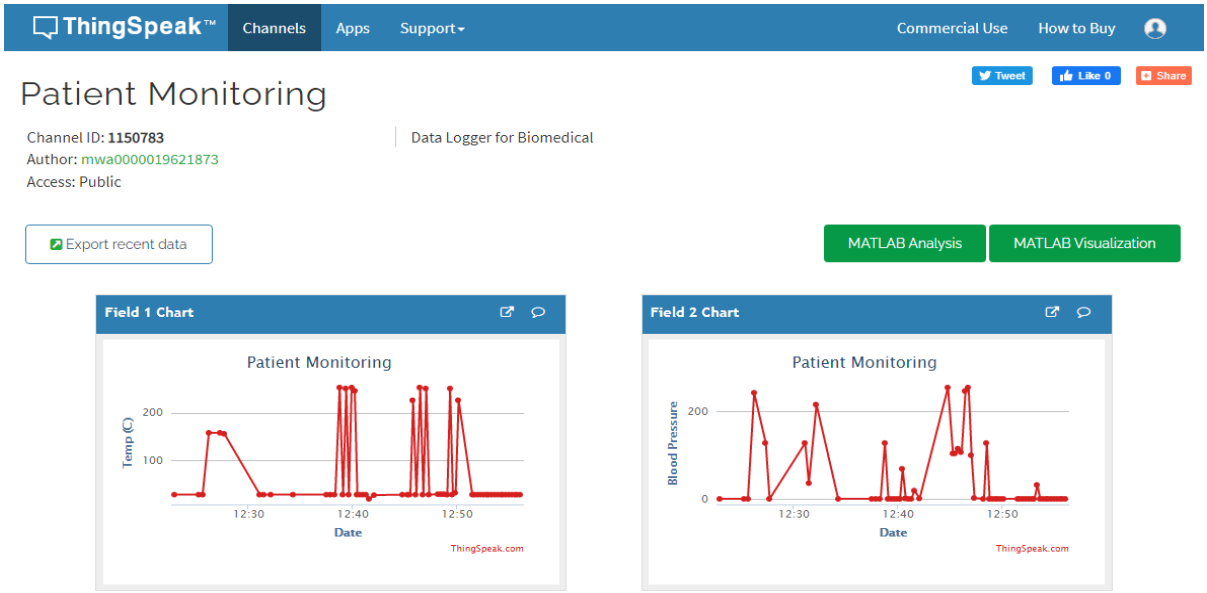

Figure 8. Temperature pressure sensors data visualization on ThingSpeak cloud.

not pass through walls may be advantageous in terms of security, it also severely restricts the range of Li-Fi. It is thus only practical in enclosed areas[7].

8. Conclusion and future scope

Instead of using Wi-Fi, the suggested system uses Li-Fi to monitor the patient. Radio interference in the human body is reduced. The health workers monitor the standard quarantine monitoring methods locally, which increases the danger of transmission. The suggested method was created in order to minimize the frequency of hospital visits, hospital lineups, and the expense of providing medical treatment to the sick. It reduces the danger of infection

by limiting intimate contact and contamination.

In the future, a huge number of patients can be monitored with this technique. Light is available and accessible everywhere, therefore, there is plenty of potential for Li-Fi technology to develop and advance. Every Li-Fi Bulb will be able to send and receive data once the technology is developed. Generally, wireless data transmission will be dominated by Li-Fi technology in the future. Due to its dynamic qualities, it is currently quite popular among wireless internet users. It is anticipated that this technology would be further investigated for laptops and other gadgets with the aid of the room's lighting.

Conflict of interest

The authors declare no conflict of interest.

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