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Iot-Based COVID-19 Remote Patient Treatment System Using Arduino

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ABSTRACT

Life expectancy has been grown dramatically in recent decades, especially in the medical field and remote treatment. For example, older persons who live alone require some medical monitoring and assistance due to mobility issues, dementia symptoms, or other health problems. In such circumstances, a self-contained support system may be beneficial. This paper proposes an indoor/outdoor Internet of Things (IoT) based information system. Recently, the number of COVID-19 cases has grown dramatically, researchers began to work on techniques to transmit and treat patients remotely. In this paper, a low-cost IoT-based system is offered to reduce the number of serious cases of COVID 19 patients and those cases may lead to death. This article introduces a device that measures and records body temperature, heart rate, and oxygen saturation levels, and then controls the oxygen level of the patient, these records will be measured and sent to the cloud server using a different sensor that is attached to the Arduino device. The results demonstrated that the data was successfully transferred to a database in the cloud.

Keywords: Mega2560**,** ESP8266-01**,** SPO2**,** Pulse Rate**,** Temperature detection**,** Valve, Relay**,** COVID-19**,** IoT

1. INTRODUCTION

Smart areas are being facilitated by recent developments in telecommunications and information systems, particularly those connected to the Internet of Things (IoT). Remote health monitoring is a common IoT application among the various services that a smart area may provide. It allows a person's health data to be continually monitored and collected, and then transmitted to a distant entity (such as a healthcare service provider) for additional processing and knowledge extraction. In remote areas of the smart region, where people have limited access to traditional healthcare services, an IoT-based remote health monitoring system might be useful. Currently, the most common application of IoT in healthcare systems is remote monitoring of a patient's [1]. Coronavirus is a broad category of viruses that can be harmful in animals or people. In 2020, IoT networks might be utilized to keep

under managing and controlling such situations. The corona virus disease, which is an infectious condition caused by the last known form of coronavirus, SARS-CoV-2, is caused by a new coronavirus that was recently found. Until December 2019, when it was found in Wuhan, China, no one had heard of this new virus or sickness [2]. According to the Centers for Disease Control and Prevention (CDC), at least seven distinct human coronaviruses have been identified so far, with the number likely to rise in the future. COVID-19 is transmitted by respiratory droplets generated by the nose or mouth when a sick person coughs, sneezes, or talks. These drops are pretty hefty and don't cover a great deal of ground. Rather, they crash to the ground fast [3]. If these droplets are breathed, COVID-19 can be contracted. As a result, it is critical that we maintain a distance of at least one meter between ourselves and others [4,5]. Around a sick individual, these droplets can be discovered on items or surfaces (tables, door handles, ramps, etc.). If someone comes into contact with certain things or surfaces and subsequently contacts their eyes, nose, or mouth, COVID-19 can be contracted. COVID-19 coronavirus incubation time, or the time between contamination and the start of the first symptoms, is typically three to five days [6]. It may, however, take up to fourteen days in certain circumstances [7]. During this time, a person may be contagious: they may have the virus before the first symptoms occur.

A new concern arises happen of patients who are secluded in their homes because their condition caused by Covid-19 is increasing and they are at risk of dying if the essential medications are not given because Covid-19 to develop, kids would typically be brought to the hospital for this follow-up, where they would undergo several tests to determine their heart rate, breathing rate, oxygen levels in the blood, blood pressure, and body temperature. The purpose of this paper is to gather data on heart rate and body temperature. The purpose of this paper is to gather data on heart rate and body temperature. Using a wireless connection, the collected data may subsequently be transmitted to a server or the cloud[8]. These are wireless links. The gathered data might be transmitted to cloud storage for long-term storage or real-time monitoring. IoT is the networked connectivity of devices (sensors and actuators) or objects (ordinary objects with internet access) to interact and transmit data without requiring human involvement; this is known as machine-machine communication, It's also used to create IoT system protocols, communication technologies, and other associated technologies, as well as domains and applications [9]. The proposed Internet of Things (IoT) infrastructure aims to monitor specific vital indicators to give early assistance in the event of any significant changes in patient healthcare, while also decreasing medical staff workload[10], as well as avoiding patient stress, which is common when a person is hospitalized, and reducing stress in medical personnel.

The paper's main objective is to provide oxygen to those who have Covid-19 symptoms [11], including as shortness of breath, irregular pulse, and altered lung function, which are comparable to pneumonia symptoms. Because the O2 level in a typical blood vessel is 75-100 mmHg, additional O2 is necessary if the dissolved O2 level is below normal, and if the O2 levels are over normal, the lungs' cells will malfunction or be damaged.

The paper is divided into: section II covers Related Work, while section III presents original work. The suggested Proposed Approach, which includes Hardware Requirements,

the cloud subsystem, and the database, is presented in Section III. Section IV depicts the theoretical framework, while Section V presents the design system with flow diagram, Section VI some outcomes and conclusions. Finally, in section VI, the conclusion is presented.

2. RELATED WORK

This section showcases a number of IoT applications and systems for healthcare and assisted living. Like, in [12], they utilized a MAX30100 Pulse Oximeter and an ESP32 to measure Blood Oxygen levels and broadcast data to the internet over a Wi-Fi network. This allows them to keep a social distance from the patients while monitoring several patients remotely. The collected information will be shown as a graph, making it easier to follow and analyze the patient's health. [3] presents a multi-sensor system for measuring the human body's heart rate and blood oxygen saturation. It is based on a Wireless Body Sensor Network (WBSN), designed as a wearable system architecture. It also includes the programming of the system code, as well as the development of the Mobile Application (APP) to display the results. The Proposed system in [13] consists of a robust microcontroller prototype that contains various sensors used to measure the user's vitals as an example heartrate, Oxygen level, and temperature, Once collected, the data is transmitted to the microcontroller (Arduino UNO) which is responsible for forwarding the data to the connected Wi-Fi module (NodeMCU), The NodeMCU takes the data from the Arduino upload the data to a private cloud server which is handled and maintained by multiple PHP scripts in the background and stored in a database. The same could be accessed via a website designed specifically for the tackling and curbing the spread of COVID-19 along with mentioning the current statistics and ways to prevent the virus. The researcher in [14] utilized sensors that can analyze and communicate data to the cloud within a set of timing, processing, and accuracy constraints. When choosing the sensors, it was important to make sure that the temperature, heartbeat, cough, and SpO2 sensors could process and show data as soon as they were taken. The sensors are connected to the Wireless module, which is in charge of sending the received data to the destination without the need for manual intervention, resulting in near-real-time transmission. Finally, integrating IoT infrastructure in the cloud ensures effective stream processing and data integration. The MAX30100 has been used in [15] along with pulse oximeter sensor, this researcher's proposed system measures the percentage of O2 rate in the circulation in actual. When compared to all other devices on the market, the high mobility, low energy, wireless connectivity, and low pricing of pulse oximeter technology are the most essential features. As a result, the initiative's original concept is to make a low-cost pulse oximeter accessible to everybody. they utilize the Inter-Integrated Circuit (I2C) addresses to distinguish between sensor data and data to be transferred to the OLED in this system since there are two I2C devices.

3. PROPOSED APPROACH

This paper will provide a proposal that has the following:

- COVID-19 safety strategy and instructions to help prevent the virus from spreading. Patients' health may be monitored in real-time by attaching numerous sensors to an Arduino board, which gathers data and sends it to a cloud storage, which might save the lives of both doctors and patients.
- a real-time emergency response, as doctors monitor the information from a far distance. This paper measures and records the heartrate, O2 saturation levels, and body temperature degree.
- Contagious illnesses will have a lower probability of spreading if implementing better surveillance systems, healthcare, and transportation are implemented.
- The cloud is used to store patient health parameter data. Because of its accessibility, cloud storage is preferable than keeping records on printed documents stored in folders. Cloud storage is even better than keeping digital documents on a specific computer, laptop, or memory device because these devices might become faulty and data can be lost [16,17].
- Hospital stays are reduced, and hospital visits for routine checks are reduced, thanks to Remote Patient Monitoring (RPM).
- Through 2019–2022, there were about 5 million people lost their life due Covid-19 [covid19.who.int].

These records will be measured and sent to the cloud server using an Arduino device with sensors (as shown in Figure 1) The heart rate and blood O2 level (MAX30100) and body temperature degree (MLX90164) sensors are connected to an AT mega 2560 microcontroller using I2C, which is one of the communicate protocols used in integrated systems. The AT mega 2560 uses Wi-Fi technology and the TCP protocol to connect to the internet [18]. The system is meant to check the patients' health on a regular basis using a collection of linked sensors. The sensors are required to collect a patient's biological parameters. The Covid-19 patients are the focus of this system. The biological measurements are then transmitted to an IoT cloud. The technology may detect life-threatening diseases and warn doctors, nurses, and hospital personnel by analysing sensor data [19,20]. This technology assists health care workers since it allows them to observe patients without having to be physically there. After the patient's approval, relatives can get restricted access to this communication.

The system will be divided into two primary subsystems: the Hardware Requirements and the cloud-based database.

3.1. Hardware Requirements

For designing the whole system, we have used some hardware as well as web technologies which will be discussed in brief below

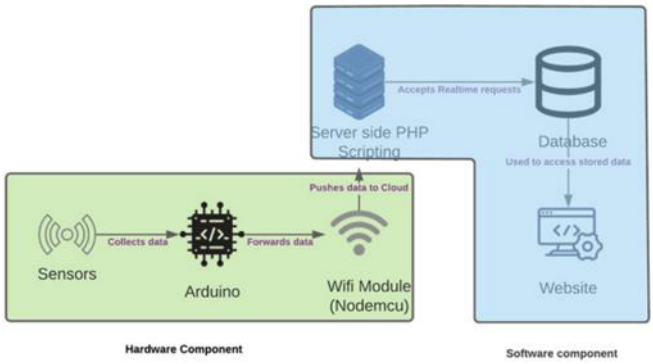


Figure 1. Architecture of the System

Table 1. Hardware requirement

List	Purpose
ATmega2560	Main controller
ESP8266	ESP8266 Wi-Fi Module
MAX30100 Sensor	Measurement Oxygen level and Heart Rate
MLX90614 Sensor	Measurement Body Temperature
Valve	Solenoid Electric Valve
Relay Module	1 Channel Relay Module 5V
OLED Display	Display result

Hardware requirements for this paper are summarized as in the Table 1

3.1.1. ATmega2560 microcontroller

The ATmega2560 is a low-power microcontroller with a high performance. It's an AVR RISC microprocessor with an 8-bit resolution. The following are the major characteristics:

- 4 KB EEPROM
- 256 KB Flash memory of the ISP
- 8 KB Static RAM
- 86 lines of general-purpose I/O
- 32 functioning registers for various purposes
- 4 USARTs
- 2-wire serial interface
- Throughput of 16MIPS at 16MHz.

3.1.2. ESP8266-01 Module

The ESP8266-01 is low price Wi-Fi module this may be used to add Wi-Fi capabilities to a microcontroller project using the UART or I2C communication protocols. The module features the following:

- 802.11 b/g/n standards
- Integrated TCP/IP protocol
- Wi-Fi Direct
- Integrated low power 32-bit CPU
- Wake up and transmit packets in < 2ms.

3.1.3. MAX30100 Sensor

The heart rate oximetry subsystem of the MAX30100 includes ambient light cancellation, a 16-bit sigma-delta ADC, and a unique discrete-time filter. It operates at extremely low power, making it perfect for battery-powered devices. The sensor requires a voltage source between 1.8 and 3.3 volts. Wearable gadgets, fitness assistance devices, medical monitoring devices, and other devices use it. Software can also be used to turn it off with very minimal standby current, enabling the power supply to remain on at all periods.

3.1.4 MLX90614 Sensor

The MLX90614 is a non - contact temperature sensor that uses Infrared (IR) technology. It can detect temperatures ranging from -70 to 382 degrees Celsius. The sensor monitors the temperature of an item and uses the I2C protocol to send it to the microcontroller.

- Voltage: 3.6 to 5V
- Current: 1.5mA
- Range: -69° C to 381° C
- Precision: 0.021° C
- Field of View: 80°
- Ambient Range: -39° C to 124° C
- Distance between sensor and object: 2cm-5cm (approxe.).

3.1.5. Solenoid Electric Valve

Uses the movement of electrons to control the flow of fluid. Any robotic project would benefit from this liquid valve. There are two 1/2" (National Pipe nominal non-taped) outputs. Normally, the valve is closed. The valve opens and liquid can flow through when 12VDC is connected to the two terminals. Because the valve includes an internal gasket, a minimum pressure of 0.02 MPa is required (3 PSI). Aside from that, liquid can only flow in one direction.

3.1.6. Relay Module

the relay is powered by the coil to produce a magnetic field and power separation between the switching pins and the coil, by connecting the Arduino kit's VCC and GND bins to the relay module kit's VCC and GND bins, coils may be easily powered from Arduino. Then,

based on the number of relays necessary in the project, we choose Arduino output pins, set them to output, and make them high (5 V) to control the relays.

Features of 1-channel relay modules

- Contact current is 10 amps at 250 volts AC or 30 volts DC.
- There is an indicator LED on each channel.
- Each channel's coil voltage is 12V.
- The kit's operational voltage ranges from 5 to 12 volts.
- Each channel's input signal is 3 to 5 volts.
- Three pins on each channel are generally open and closed.

3.1.7. OLED display

It has a 0.96" screen with a resolution of 128x64 pixels and the SSD1306 driver. It can be connected to a microcontroller via I2C (its address is 0x3C not 0x78 as printed on the PCB).

Specification:

- Driver: SSD1306
- Size: 0.96"
- Resolution: 128x64 pixels
- Voltage: 3 to 5 volts
- Dimensions: 22x11 mm.

3.2. CLOUD SUBSYSTEM

This subsystem makes use of a database that collects necessary data from of the query string and allows quick access to the system's data. In these data structures, indexes are employed to speed up data access. The application that was utilized to build this database, phpMyAdmin is a PHP program that allows you to manage MySQL databases from anywhere in the world. It can handle a wide range of MySQL and MariaDB operations. Databases, tables, columns, relations, indexes, users, permissions, and other procedures are some of the most often used processes. It's feasible to do it using the user interface, but users may also manually run each SQL statement.

4. DESIGN SYSTEM

Figure 2 depicts the system's block diagram. It is made up of several blocks. All processes will be controlled by the MEGA 2560. We can program MEGA 2560 and link circuits to it. The MAX30100 integrated IC, which is a tiny, low-cost integrated solution for sensing heart rate and pulse oximeter, is used in the Pulse Oximeter and Heart Rate Sensor module as well as ambient temperature using the MLX90614 temperature sensor. The MEGA 2560's output will be displayed on the web through Wi-Fi. All Pulse Oximeter has an IR led and a RED led. If one places one's finger on this sensor, the red-light travels into one's skin, and the IR led receives it. The O2 level in the blood is measured using both red and infrared LEDs.

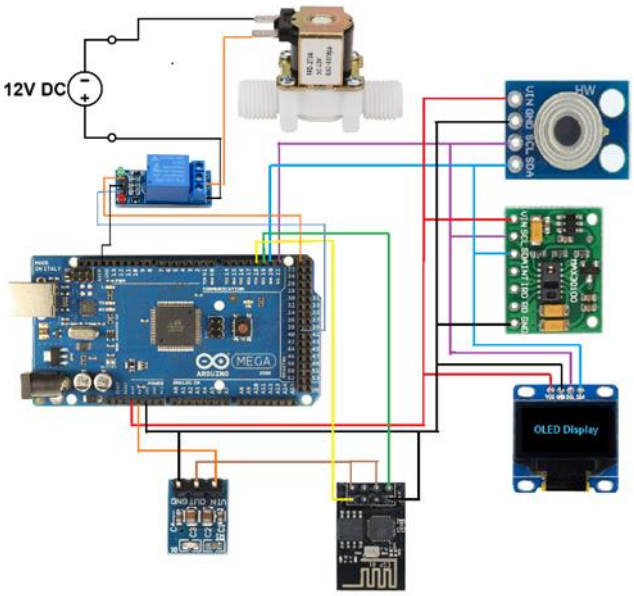


Figure 2. Connection the electronic circuit with sensors

The MLX90614 is a digital temperature sensor that could be used to monitor temperature. The sensor measures body temperature using infrared radiation without requiring any physical touch, both sensors (MAX30100 and MLX90614) communicate with the microcontroller via the Inter-Integrated Circuit (I2C) protocol, which detects a beat after a finger is placed on the MLX30100 for ten times and sends the sensor into shutdown mode, with the most recent reading saved and sent serially to the Wi-Fi module via Inter-Integrated Circuit (I2C).

The Solenoid Electric Valve is connected to an oxygen bottle and the second side to a face mask that control by a relay to open it and close depending on the last reading from the MAX30100 sensor that saved in Microcontroller if the oxygen level is less or equal to 94% the relay will receive signal 5v from the microcontroller to make valve to open to get the patient on oxygen if the oxygen level greater than 94% the valve will stay close.

Figure. 3 shows Proposed System Flow Chart. A patient's finger should be placed on the sensor probe. On the probe, a light source produces light, and a receiver acts as a light sensor (photodiode).

The programming method is divided into two parts: ESP8266 programming and ATMEGA 2560 (inter-integrated circuit) (I2C) programming.

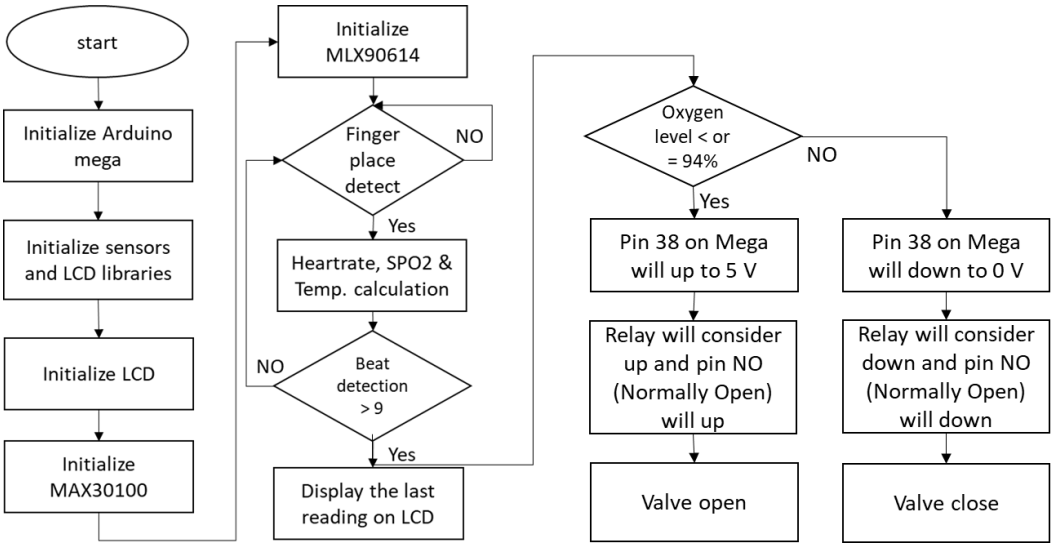
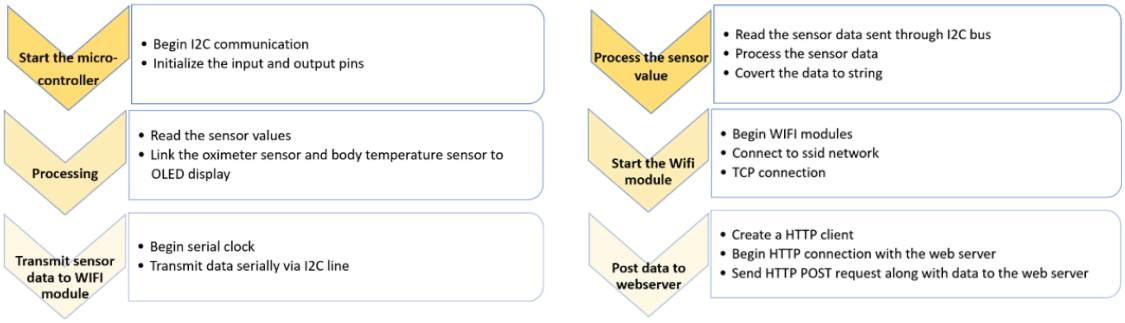


Figure 3. Proposed System Flow Chart.



(a) (b)

Figure 4. (a) Microcontrolar start process, (b) Read data from sensor

4.1. Programming the ESP8266 with the Arduino IDE

Figure 5. shows the Wi-Fi module that works connected to the SSID network that comment used:

AT+CWJAP= "name of SSID", "security password"

Send data across a TCP connection once a connection has been established.

• if there is a connection, send OK

– SEND OK

• if there is no connection, unable to send

– SEND FAIL

• if Detect TCP disconnect

– CONNECTION CLOSE

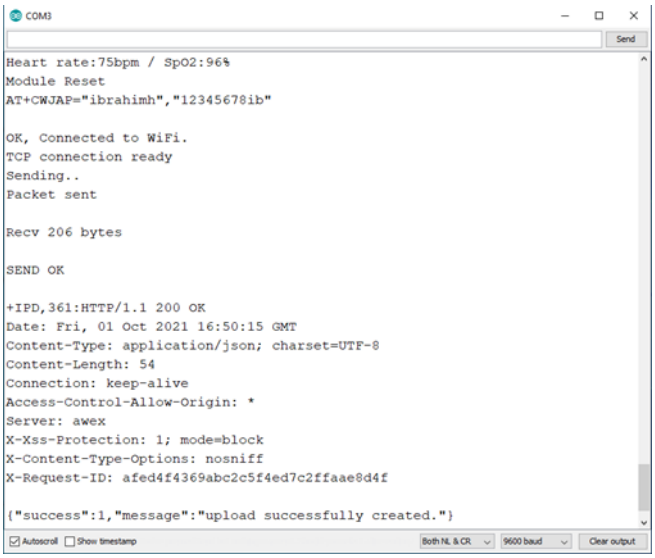


Figure 5. Arduino IDE Result

4.2. Programming Arduino ATMEGA 2560

When you get SEND OK, as seen in Figure 5, the data from the Arduino is first sent to the Wi-Fi module, then sent to the web server over the internet, where it is saved in the PhpMyAdmin table.

4.3. Design and implementation of a web server and web page

One of the most crucial components of the system is the web server. It is in charge of processing requests from the Microcontroller and the sensor device. The web server is housed on the cloud hosting platform 000webhost.com. PHP is used on the web server and mostly works with json and txt files. Some code in the PHP script does some basic processing and saves the data gathered by the PHP script's $_POST super global variables. For each device and sensor, the PHP script is used. The query string provided to the URL is used by the web server to obtain the appropriate data. HTML, CSS, and JavaScript are used to create the website. HTML is used to describe a web page's text, CSS is used to define a web page's structure, JavaScript is being used to program the actions of a web page. The website may be viewed by clicking on the following link covid19a.000webhostapp.com/apl as it is shown in Figure 6.

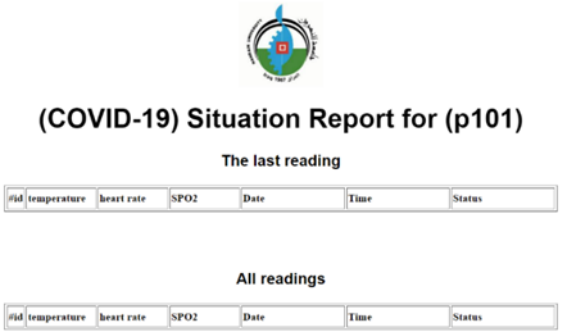


Figure 6. Webpage Design

5. RESULTS

The MAX30100 sensor's precision in detecting blood oxygen saturation and heart rate, as well as the MLX90614 sensor's measurement of body temperature, are connected via Mega 2560 through I2C, which is already incorporated on both devices, in this research tool. After the data is received by the Mega 2560, it is serially transmitted to the ESP8266. The data received by the ESP8266 is transmitted to the Database Server over the Wi-Fi network that the device is connected to.

The Solenoid Electric Valve has controlled the oxygen that goes to the patient if less or equal to 94% the valve will open and the patient will get oxygen from the oxygen bottle that will make fast treatment to increase oxygen in the blood of the patient.

The Doctors will remotely monitor heart rate, oxygen saturation levels, and body temperature on a Website that records in a cloud server. If the oxygen level is less or equal to 94% that alarm will show As Figure 8 also with sound alarm.

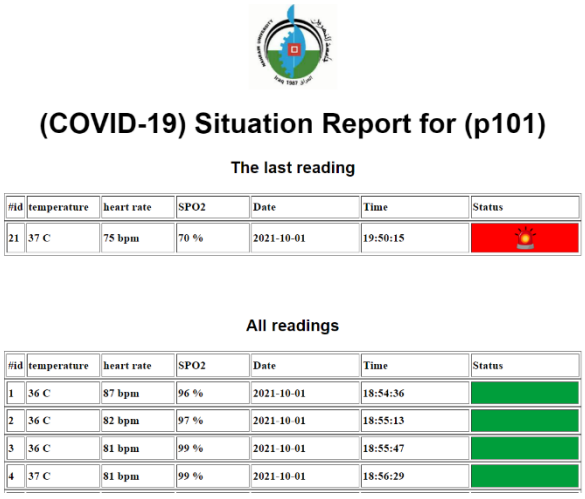


Figure 8. View Program Upload Results

6. CONCLUSION

This method is quite useful for patients or suspected instances of Covid-19 who are at home, since it allows for quick treatment and monitoring of the patient's condition. In a separate approach, it will aid medical professionals by keeping them from being exposed to a large number of Covid-19 positive individuals and risking infection, as well as removing the face-to-face follow-ups that are presently carried out on isolated positive individuals in their homes. In hospitals and clinics, medical workers will always be required, This system will assist in lowering the amount of patients that visit hospitals, allowing staff to concentrate on the most critical cases and, to some extent, minimizing stress and anxiety associated with exposure to and interaction with so many patients.

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