Private Backend Server Software-Based Telehealthcare Tracking and Monitoring System

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Abstract—In these recent years, the world has witnessed a kind of social exclusion and the inability to communicate directly due to the Corona Virus Covid 19 (COVID-19) pandemic, and the consequent difficulty of communicating with patients with hospitals led to the need to use modern technology to solve and facilitate the problem of people communicating with each other. healthcare has made many remarkable developments through the Internet of things (IoT) and cloud computing to monitor real-time patients' data, which has enabled many patients' lives to be saved. This paper presents the design and implementation of a Private Backend Server Software based on an IoT health monitoring system concerned with emergency medical services utilizing biosensors to detect multi-vital signs of an individual with an ESP32 microcontroller board and IoT cloud. The device displays the vital data, which is then uploaded to a cloud server for storage and analysis over an IoT network. Vital data is received from the cloud server and shown on the IoT medical client dashboard for remote monitoring. The proposed system allows users to ameliorate healthcare jeopardy and minify its costs by re-cording, gathering, sharing, and analyzing vast biodata streams such as Intensive Care Units (ICU) (i.e., temperature, heartbeat rate (HR), Oxygen level (SPO2), etc.), efficiently in real-time. In this proposal, the data is sent from sensors fixed in the patient body to the Web and Mobile App continually in real time for collection and analysis. The system showed impressive performance with an average disparity of less than 1%. body temperature, SPO2, and HR readings were remarkably accurate compared to the CE approval patient monitoring system. In Addition, The system was highly dependable with a success rate for IoT data broadcasts.

Keywords—Internet of Things (IoT), Wireless Body Area Sensor Networks (WBASN), COVID-19, artificial intelligence (AI), cloud computing

1 Introduction

The coronavirus disease (COVID-19) epidemic is the most serious threat to humanity in recent years and the most significant global health issue [1]. Globally, there have been about 514 million confirmed cases of COVID-19, including about 6.3 million deaths, according to the World Health Organization's (WHO)infections of 6 May 2022 [2]. The SARS-CoV-2 virus is the infectious virus responsible for COVID-19 [3]. The virus is transmitted by contacting a contaminated surface or by the respiratory droplets of an infected person. Symptoms can include a high fever, cough, difficulty breathing, and body aches according to the Centers for Disease Control (CDC) [4][5]. Sometimes, patients do not recognize the symptoms and cause subsequently die without receiving proper treatment Therefore, it is important for persons to regularly check up on their health conditions, especially body temperature, HR, and SpO2. but due to the imposing quarantine which was identified as an efficient measure to curb the spread of the virus worldwide. it may be difficult for most people to get regular health checkup appointments, specifically for oldsters (over 60) and individuals who have weak immune systems or chronic disease issues [6].

One solution to decrease the disease's spread by taking early diagnostic steps and reducing the effect of the disease's symptoms while staying at their home with the help of the Potential Infected Patient Monitoring (PIPM)process [7][8]. PIPM is achieved by utilizing the Internet of Things (IoT) with Wireless Wearable Health Devices (WWHDS) [9]. WWHDS consists of several sensor nodes placed on or implanted in a human body that record the patient's vital signs such as temperature, O2 saturation, HR, and other respiratory information [11][12]. IoT devices are microcontrollers that collect, analyze, and monitor the WWHDS biodata and then manage and store the disease symptoms remotely in the cloud via the Internet and then transferred them to a healthcare center where clinicians can investigate the information via their web or phone application to identify abnormal activities and send precautions to patients on time before severe damage [13][14]. As a result, IoT systems improve the COVID-19 healthcare system by being utilized to track medical supplies convey, and send and receive medical data through wearables. Therefore, Doctors can more easily examine, diagnose, and treat patients by utilizing IoT-based telemedicine technology without physical contact [10]. Figure 1 illustrates the IoT with cloud-based COVID-19 patient health monitoring.

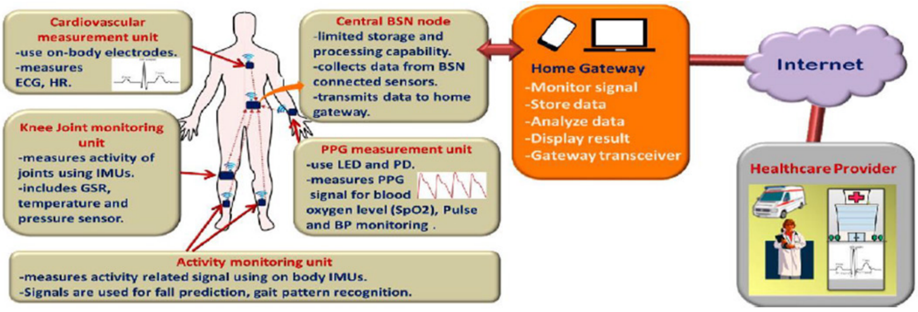

Fig. 1. The architecture of a wearable health-monitoring system

In recent years, IoT has rapidly developed by integrated with artificial intelligence (AI) techniques to enhance intelligence, modality, and care [15]. many wearable IoT devices (WIoT) were developed such as microsensors that are embedded in various costume parts (such as t-shirts, glasses, or belts), computerized watches, etc. [16].

Many designs and researches are related to the continuous health monitoring system, which describes the vital signs among the most crucial physiological signals of the human body. Valerie GAY et al. [17] designed a smartphone and wearable sensors for monitoring the ECG trace in real time. they used wireless and smartphones to analyze the high risk of cardiac. They classified the solutions into two groups: The first group uses smartphones with biomedical sensors to measure heart activity and then transmits these signals to the hospital. The second group designed a device for real-time remote monitoring. In this study, the heart rate detector has a sensitivity value of 99.4% when compared to the patient monitor system. Y. Baptista et al. [18] used A web application remote health-monitoring system based on Enterprise Service Bus (ESB). they used Web services interfaces to expose the transmitted data to the monitoring influx within the ESB and smartphone gateway placed with the patient to work as a data sink for on-body Wireless Body Area Networks (WBAN) sensors worn by the patient. they used Simple reasoning processes executed by the smartphone application before broadcasting the collected data to the monitoring system through the Internet.

H. Jianqiang et al. [19] designed a Cloud assisted home health monitoring system. they used a smartphone and Xiamen Health Cloud to receive vital signals and store them. the system gives positive import to chronic diseases patients that allow health monitoring and services from home. Fajar M.R. et al. [20] studied the effect of heart health on the human body. The researchers show aside from the ECG, heart health can be specified by measuring the blood pressure of the subject. Blood pressure in some patients show a good result, thus the health of some patient cannot be immediately diagnosed at the healthcare Centre. For this reason, the need of continuous monitoring of blood pressure is needed. In this study, the researchers designed a mobile blood pressure for real-time measuring the blood pressure and automatically sent the data to the doctor or hospital via SMS. The device was smart and fast transmitted the data; it will take about 46.27 seconds for each measurement. Kadave A.R etc. [21] utilized the internet of things (IoT) to monitor patients' multiple characteristics. they transferred real-time parameters to the cloud through connect the monitoring device to the internet. they suggested a tool linked to a computer wirelessly that provides real-time monitoring and is managed by the patient. the result demonstrates the significance of measuring vital signals during activity and moving medium to check a patient's health. Dong et al. [22] designed a wearable device for continuous blood pressure (CBP) monitoring [23], but it did not keep health data for further study. Aadil et al. [24] proposed a wireless body area network (WBAN) for remote health monitoring that utilized the IoT. Li et al. [25] created a ZigBee network to connect devices to a base station. Fu et al. [26] used a wireless sensor network and a Wi-Fi transmission protocol to evaluate oxygen saturation, although he looks at only one indicator, making it difficult to evaluate overall health. Raileanu et al. [27] analyzed the questionnaires anonymously on an internet platform after analyzing the MAST (Model for Assessment of Telemedicine) in the Cardiology department. The application passed the MAST test, proving that the created telemedicine solution for cardiac patients serves its secondary prevention goal. Sabukunze et al. [28] proposed an IoT concept for smart malaria patient monitoring and alert systems. They concluded that a smart monitoring and alert system is critical for monitoring malaria patients and can warn them in the event of a serious situation. Nagarjuna et al. [29] discussed the real-time temperature and humidity monitoring scenario. They conclude that the critical scenario can be averted and preventive measures successfully taken by using a Virtual Instrumentation (VI) server and a data gathering web application using a regular web browser.

This paper uses web and mobile apps with ESP32 microcontrollers and biosensors to monitor patients' status. The collective parameters related to the severe problem are collected from the patient. This data given to two different interfaces included vital parameters and displayed details. This collected data is given to a web-based server as well as a mobile app, so the presented data can be checked by the doctors at any time with the help of their computer or smartphone, it helps them to examine and send precautions to patients and their family members at the same app, at the same time reminding them to take his medication on time before severe damage [30]. IoT plays an important role which offers live, fair, and comprehensive monitoring taking the edge off the patient's governess support to make medical assistance [31].

This study is organized as follows. In Section 2 the wearable is described by providing the specifications of instrumental sensors for its development besides the algorithmic process adopted is presented. Section 3 includes the results stemming from the present study. Lastly, in Section 4, concluding remarks and discussion on future research steps are provided.

2 Materials and methods

This system proposed wireless sensor implementation for 24*7 and provides health parameters by monitoring them without interrupting daily routine. For this fixed and mobile body sensors are used with a desperate algorithm. This helps for positing and analyzing patients' health and to take additional decisions about patient health. The given architectural model is in the Figure 2 shows the basic structure of the presented technique, in which the MLX90614 sensor is used to detect the fever and the MAX30100 sensor to detect oxygen level and heartbeat then their output sends to ESP32 Ardunio. The messages can be read by web or android app on the computer or smartphone of the patient's doctor and caretaker to assist them and at the same time, the patient's health history is also has been saved on a cloud database.

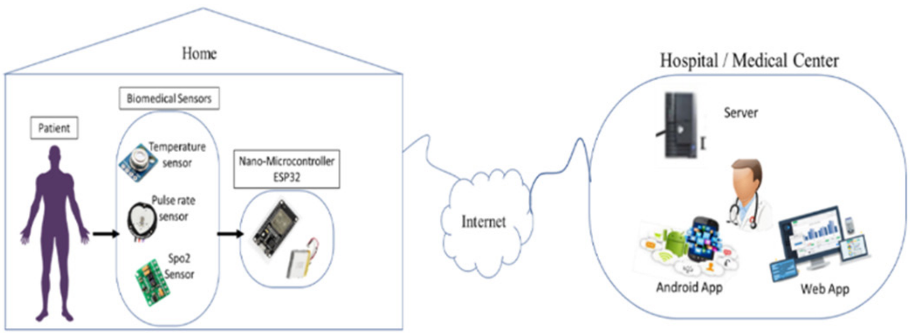

Fig. 2. The architecture of biosensors for remote healthcare monitoring system

The design of the system consists of three stages. The first stage is the hardware components which consist of (a microcontroller, biosensors, and server for both mobile and web applications) as shown in Figure 3. A second stage is the software REQUIREMENTS that program these biosensors to connect to the microcontroller and monitor the parameters and finally, in the third stage all of the systems are packaged in one small device to be wearable to the patient.

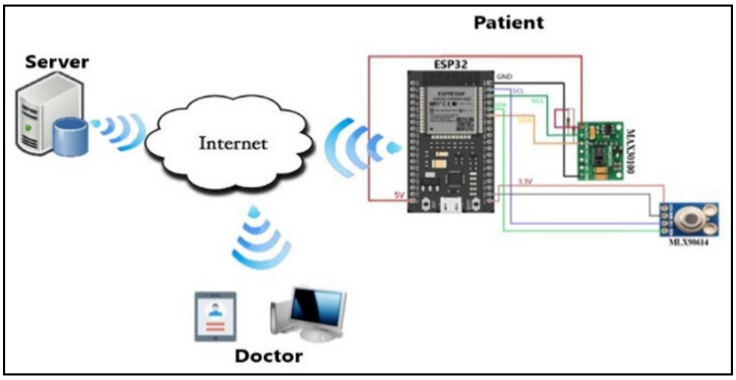

Fig. 3. The schematic diagram for the hardware configuration

2.1 Hardware components

ESP32 microcontroller. ESP32 shown in Figure 4 is low power and low-cost microcontroller chip designed by Espressif in Shanghai, China. It has integrated Wi-Fi with dual-mode Bluetooth radios. It has many of the capabilities of the Arduino that is programmed using the Arduino IDE software and so is a soft upgrade path for applications that needs wireless communication. The ESP32 is an upgrade of the earlier ESP8266 and adds a faster dual-core processor and Bluetooth interface. In the proposed system, ESP32 considers the core of the system which is used to collect the patient's vital signs via biosensors and then process the data and sent it via WIFI network to a central server that allows displaying the data on the mobile and web applications for both patient and doctor.

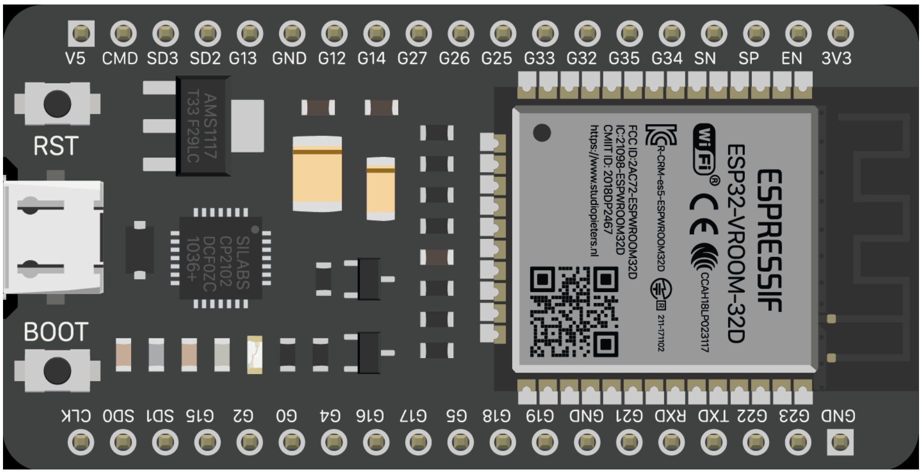

Fig. 4. ESP32 with Nodemcu

MAX30100. The MAX30100 is a sensor used to measure the heartbeats per minute and the concentration of oxygen in the blood. The sensor has two LEDs; one is used to emit infrared light to measure heart rate and the other to emit red light to measure with the first the SPO2 in blood. It has seven pins each one has its function as shown in Figure 5 [32].

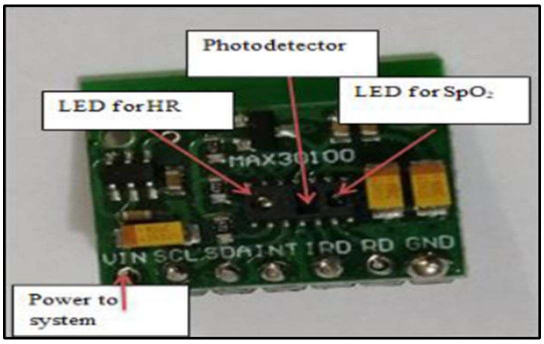

Fig. 5. The MAX30100 pins description

Auto calculate the percentage of oxygen saturation follow the formula at eq.1

$$Spo2 = 110 - 25\left(\frac{RED\ LED\ Level}{IR\ LED\ Level}\right) \tag{1}$$

MLX90614. MLX90614 as shown in Figure 6 is a temperature measurement device that works on infrared radiations. It is the best option for such applications because it provides non-contact measurement of temperature. It consists of a squatnoise amplifier, 17-bits Analog-to-Digital and an efficient digital signal processor (DSP) component.

These components give the sensor a high accuracy and degree. this sensor uses an infrared light detector with Advanced Solid-State Photonics (ASSP) signal conditioner for processing the output [33].

Fig. 6. The MLX90614 pins description

Server. A server is a computer system that makes resources, information, services, or programs available across a network to other computers or mobile devices known as clients. Theoretically, computers are regarded as servers whenever they share resources with client devices as illustrated in Figure 7. Web servers, mail servers, mobile servers, and other sorts of servers are only a few examples. In the proposed system, this hardware part is used to build web and mobile services to be used by both the patient and doctor to view the patient's information on their computer or phone.

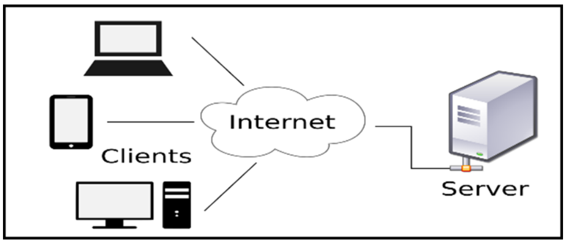

Fig. 7. A diagram of a computer network showing a client connecting to a server computer over the Internet

2.2 Software requirements

The Integrated Development Environment (IDE) is a cross-platform (Windows, macOS, Linux) application written in C and C++ functions. It's used to program microcontroller-compatible boards and upload them.

Web application. Nowadays, the number of Web Frameworks has increased greatly. It can safely accelerate and extend work, including allowing the production of a responsive and more attractive web app. Because so many web frameworks currently rely on Modules, View, and Controller (MVC), ReactJs was chosen to design and run the web application as shown in Figure 8. React makes creating interactive user interfaces (UIs) a breeze. it will update and render only the necessary components as the data changes, it is used by FACEBOOK. Declarative sights make coding more predictable and debugging easier. Also, React is used to create mobile applications (React Native). React employs one-way data binding and the Flux application architecture, which manages the flow of data to components through a single point of control.

Fig. 8. Run react app

The application consists of a page that defines the user as a doctor or patient, a login page, a dashboard that sees all patients roll with their doctor, and a page for monitoring patients provided by graph history as shown in Figure 9.

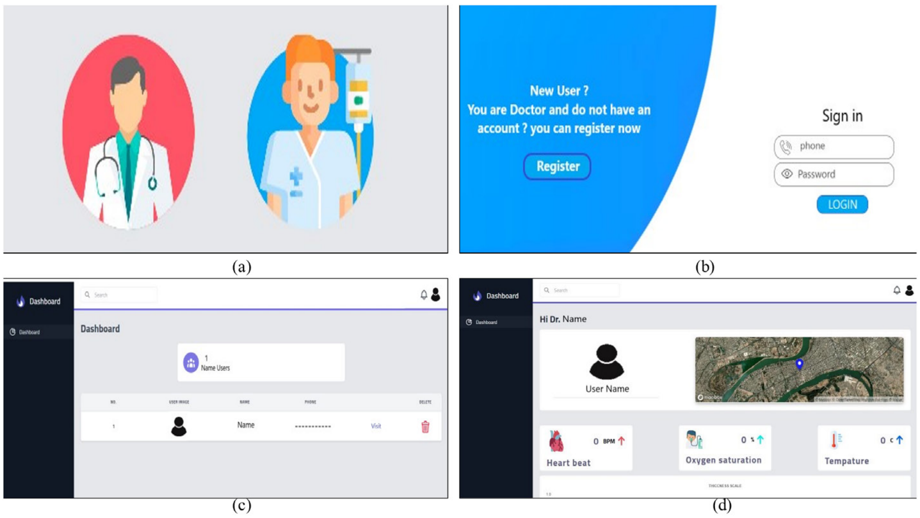

Fig. 9. (a) User page, (b) Login page, (c) DashBoard, (d) Monitoring Page

For a mobile application as shown in the Figure 10, A flutter framework is used to develop a native cross-app. Framework Widget Library is used to create things like user interfaces and building blocks. Then with the help of the Software Development Kit (SDK) convert the app created into native machine code.

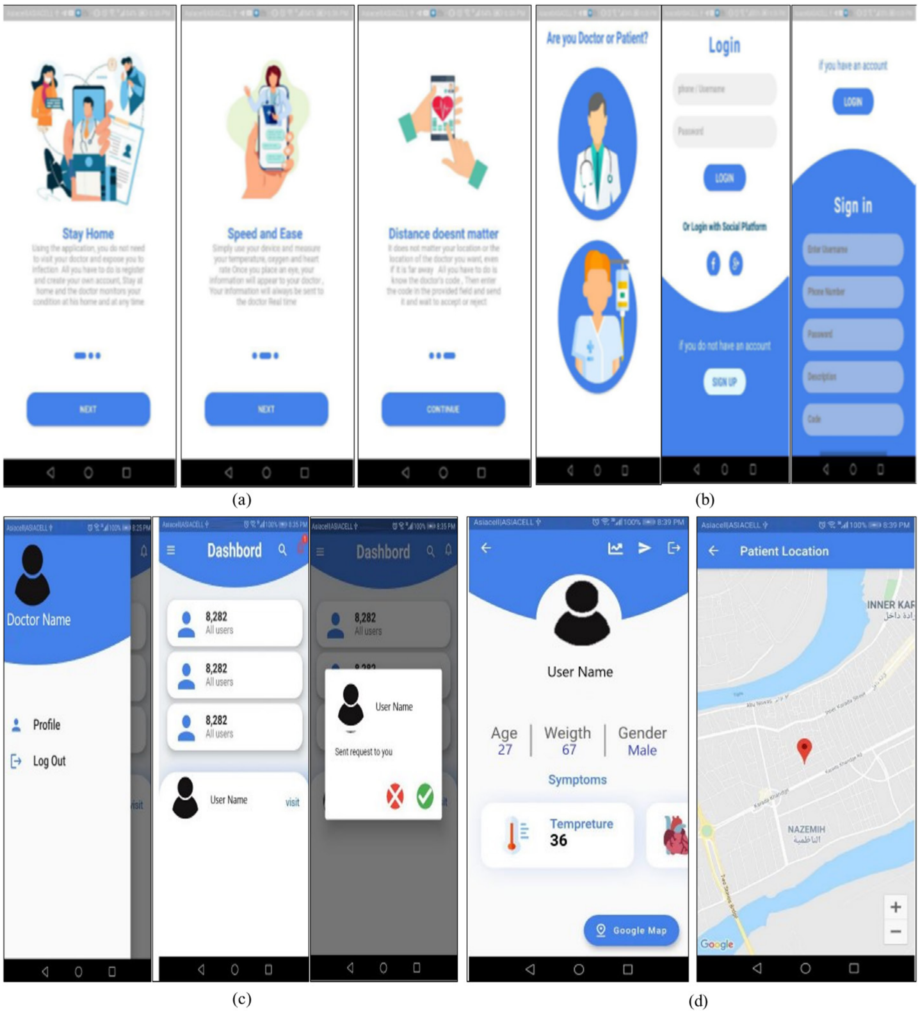

Fig. 10. (a) Onboarding pages (b) Login and Sign in (c) Dashboard for doctor and how to receive a request (d) Patient Profile and his location

3 Results and discussion

The validation of the present system was achieved by comparing the results of the proposed system with the patient monitoring system that is used in the hospital (CE approval). The results were obtained from 17 subjects (some of them healthy and the others are severed from some disease) of different sex and ages. The results of the vital signs of the human body were obtained from two sources, the first one is the data obtained from the IDE software and CE approval patient monitoring system as illustrated in Table 1.

Table 1. Results of 17 subjects are obtained from the IDE software compared with CE approval patient monitoring system

Pt.	IDE Software			CE Approval Patient Monitoring System		
	SPO2	Temp. (°C)	HR	SPO2	Temp. (°C)	HR
1	96	35.8	81	97	36.4	82
2	98	36.3	83	99	36	84
3	97	36	86	96	36.3	85
4	96	36.2	80	97	36	81
5	96	36.3	80	97	36.7	79
6	96	36.1	79	97	36.3	78
7	95	36.4	69	96	36	68
8	98	35.6	78	99	35.8	79
9	97	36.5	80	96	36.2	81
10	98	35.5	87	97	35.9	88
11	96	36	80	97	35.8	81
12	97	36.2	80	98	36.4	79
13	96	36.5	77	97	36.3	76
14	95	36.1	75	96	36.4	74
15	96	36.6	87	97	36.2	86
16	98	35.9	88	99	35.8	87
17	95	36.1	75	96	36.3	74

As illustrated the results are very approximate in all vital signs (SPO2, Temp., and HR). So the device has the ability for detecting any changes that been happened to the patient directly. Table 2 shows the measuring of the percentage errors of the present system against the CE approval device. This is done by using the equation: [34]

$$Error\,(\%) = \frac{MV - CV}{CV} \times 100\% \tag{2}$$

Table 2. The measuring of the errors (%) of the present system against the CE approval device

Pt.	SPO2 (%)	Temp. (%)	HR (%)
1	1.031	1.648	1.220
2	1.010	0.833	1.190
3	1.042	0.826	1.176
4	1.031	0.556	1.235
5	1.031	1.090	1.266
6	1.031	0.551	1.282
7	1.042	1.111	1.471
8	1.010	0.559	1.266
9	1.042	0.829	1.235
10	1.031	1.114	1.136
11	1.031	0.559	1.235
12	1.020	0.549	1.266
13	1.031	0.551	1.316
14	1.042	0.824	1.351
15	1.031	1.105	1.163
16	1.010	0.279	1.149
17	1.042	0.551	1.351

Where MV is the measured value of the present device and CV is the controller value of the CE approval device. The second result of the vital signs of the human body was obtained from the IoT spatial software (Thinger.io program) as illustrated in Table 3.

Table 3. Results of 17 subjects are obtained from the IoT software

Pt.	SPO2	Temp. (°C)	HR
1	96	35.8	81
2	98	36.3	83
3	97	36	86
4	96	36.2	80
5	96	36.3	80
6	96	36.1	79
7	95	36.4	69
8	98	35.6	78
9	97	36.5	80
10	98	35.5	87
11	96	36	80
12	97	36.2	80
13	96	36.5	77
14	95	36.1	75
15	96	36.6	87
16	98	35.9	88
17	95	36.1	75

As illustrated in Figure 11, the resulting data transferred through the network from the IDE software and IoT spatial software are synchronized in real-time and matched. Therefore, the doctors can diagnose any change that will occur in the vital sign.

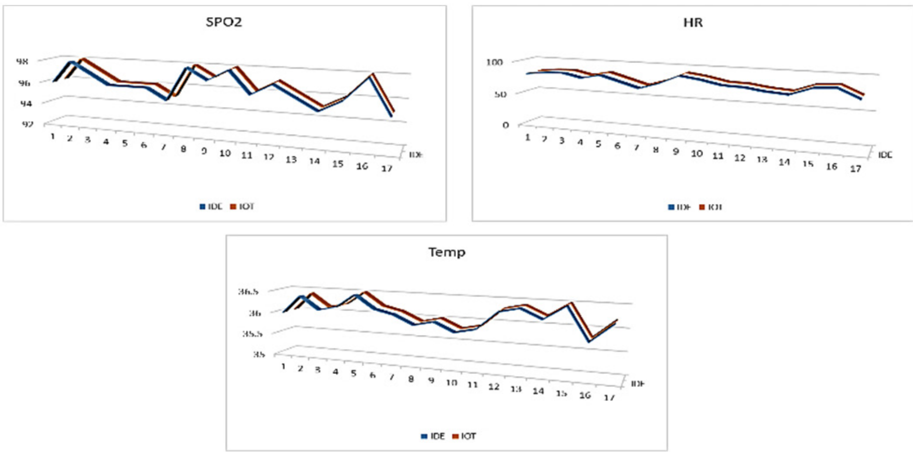

Fig. 11. Data obtained from the IDE software and IoT spatial software

4 Conclusion

This research presents a design and implementation of a Private Backend Server Software based on an IoT health monitoring system concerned emergency medical services and other health issues of COVID-19 patients' monitoring utilizing biosensors to detect multi vital signs of an individual with an ESP32 microcontroller board and IoT cloud. The proposed system is efficient, and economical, and allows continuous faraway Healthcare for patients with COVID-19, the Intensive care unit (ICU), or also the ever-increasing demography of elders. The proposed system enables hospitals and medical centers to continue storing and monitoring patients' vital medical signs like fever, oxygen level, heart rate, etc. while staying at their home. At any abnormality, it gives an alert to the centers, and medical staff or specialist doctors can monitor, localize, and instruct patients online. likewise, patients can ask their queries to their remote doctors too. In the proposed system the data can be made available for remote use and only to authorized users, such as distant specialist doctors and specified patients. As a result, design parameters such as availability, security, correctness, and efficiency are successfully met. The given results of observations have been shown successfully with high accuracy, precision, and gain. The system showed impressive performance with an average disparity of less than 1%. body temperature, SPO2, and HR readings were remarkably accurate compared to the CE approval patient monitoring system. In Addition, the system was highly dependable, with a success rate for IoT data broadcasts. In future work, it is possible to improve the system accuracy by utilizing blockchain technology and trying to make the wearable gadget smaller to make them more user-friendly. Also, Cyber-attacks can compromise IoT devices. As a result, data traveling from the system to the cloud must be coded, and implement security strategies to prevent cyber-attack.

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