Detection and monitoring of the asymptotic COVID-19 patients using IoT devices and sensors

Rajeesh Kumar N.V. and Arun M.
Department of Computer Science and Engineering, Amrita College of Engineering and Technology, Nagercoil, India

Baraneetharan E.
Department of Electrical and Electronics Engineering, Surya Engineering College, Erode, India

Stanly Jaya Prakash J.
Department of CSE, Mahendra Institute of Technology, Namakkal, India

Kanchana A.
Department of CSE, Mahendra Engineering College For Women, Namakkal, India, and

Prabu S.
Department of ECE, Mahendra Institute of Technology, Namakkal, India

Received 12 August 2020
Revised 13 August 2020
Accepted 13 August 2020

Abstract

Purpose – Many investigations are going on in monitoring, contact tracing, predicting and diagnosing the COVID-19 disease and many virologists are urgently seeking to create a vaccine as early as possible. Even though there is no specific treatment for the pandemic disease, the world is now struggling to control the spread by implementing the lockdown worldwide and giving awareness to the people to wear masks and use sanitizers. The new technologies, including the Internet of things (IoT), are gaining global attention towards the increasing technical support in health-care systems, particularly in predicting, detecting, preventing and monitoring of most of the infectious diseases. Similarly, it also helps in fighting against COVID-19 by monitoring, contract tracing and detecting the COVID-19 pandemic by connection with the IoT-based smart solutions. IoT is the interconnected Web of smart devices, sensors, actuators and data, which are collected in the raw form and transmitted through the internet. The purpose of this paper is to propose the concept to detect and monitor the asymptotic patients using IoT-based sensors.

Design/methodology/approach – In recent days, the surge of the COVID-19 contagion has infected all over the world and it has ruined our day-to-day life. The extraordinary eruption of this pandemic virus placed the World Health Organization (WHO) in a hazardous position. The impact of this contagious virus and scarcity among the people has forced the world to get into complete lockdown, as the number of laboratory-confirmed cases is increasing in millions all over the world as per the records of the government.

Findings – COVID-19 patients are either symptomatic or asymptotic. Symptomatic patients have symptoms such as fever, cough and difficulty in breathing. But patients are also asymptotic, which is very difficult to detect and monitor by isolating them.

Originality/value – Asymptotic patients are very hazardous because without knowing that they are infected, they might spread the infection to others, also asymptotic patients might be having very serious lung damage. So, earlier prediction and monitoring of asymptotic patients are mandatory to save their life and prevent them from spreading.

Keywords Sensors, Asymptotic

Paper type Research paper

International Journal of Pervasive Computing and Communications

1742-7371
DOI 10.1108/IJPCC-08-2020-0107

1. Introduction

Internet of Things (IoT) is almost the entirety of our daily life. They are used everywhere such as home, hospitals and education, where they can be installed outside to control and report the changes in the environment such as fire prevention in every field and many other beneficial functionality. IoT is a collection of things, which is entrenched with electronics, sensors, actuators, software and all these are connected through the internet to collect and exchange the data with each other. These IoT devices use different sensors and actuators and are armed with processing power, which enables them to deploy in many atmospheres (Yang *et al.*, 2016). The major important job of IoT is to improve the nature of our lives. The five major principles of IoT parts are given as exceptional identification, detecting gadget, correspondence, information stockpiling and investigation and perception. The major applications where the IoTs are deployed are medical application, smart home, vehicle management, agriculture and smart cities (Shirode *et al.*, 2018).

The data transmission in IoT is done through the internet from one device to another device, so it is defined as a connection between the physical objects such as sensors, actuators, any object, road, buildings, vehicles and even humans. Everything is connected and entrenched with the micro-controller and network connectivity where it exchanges the data from one object to another (Gurjar and Sarnaik, 2018). The technology of the IoT can deliver a huge amount of data regarding objects, time, space and also humans. IoT provides a huge amount of space and advanced service on sensors and wireless communication. There are many people in the world whose health may suffer because of lack of proper access to the hospitals and health monitoring, which can be done by IoT. IoT is an internetworking of any device, vehicle, object, buildings and other items embedded with all the electronic devices such as sensors and actuators that enable us to collect and exchange the data (Saranya and Maheswaran, 2019).

The IoT-based smart irrigation system considered with many sensors to wrinkle farm field data, and put away all the data in the cloud for the development of irrigation (Hegde and Mundada, 2020). IoT and cloud-based methodology are used for an automated disease predictive system that uses sensors and other devices to measure the various parameters of the patient such as blood pressure, heartbeat rate and temperature. The data which are received from such sensors are sent to the doctor through the cloud; hence, using this method, doctors can take the correct decision by analysing the data to give medical treatment (Dhivya and Parameswaran, 2020). Chronic diseases such as cardiovascular disease, chronic kidney disease and diabetes may continue for a long time (Krishna and Sampath, 2017). The major benefits of the IoT in health-care systems are decreased costs, easy analysis of disease, quick conclusions of treatment, disease management and enhanced management of drugs. It is possible to monitor the patient's health with sensors input and output signals effectively (Ramadass *et al.*, 2020).

Coronavirus outbreak spread from Wuhan, China appears to be unstoppable. This genus beta coronavirus causes the Middle Eastern respiratory syndrome and severe acute respiratory syndrome (Chamola1 *et al.*, 2020). COVID-19 is one of the most severe pandemic illnesses we are confronted with now. It is profoundly infectious. It spreads and influences various individuals in various manners. Infected people may encounter gentle to direct treatment and recoup with no exceptional treatment. There are numerous indications, however, most regular side effects are fever, dry cough and breathing problem (Rahman *et al.*, 2020; Reddy and Sankara, 2018). But people can also be with crown infection that are asymptotic with no regular side effects. People are at high risk with numerous different complexities such as hypertension, diabetes, cardiovascular sickness and so on. The fast ascent in the quantity of COVID-19 occurrences around the world has incited the

requirement for guaranteed countermeasures to control the calamitous impacts of the COVID-19 episode (Reddy and Sankara, 2018).

In this circumstance, there is no specific immunization or any treatment for this infection; it is exceptionally significant for the humans to keep up social distancing, usage of masks and sanitizers. As a result of this policy reviews, whether individuals are keeping up social distancing through automatons, which sends the alarm message to the police headquarters when individuals are disregarding the standards (Rahman *et al.*, 2020; Reddy and Sankara, 2018). At this point, the infection is spreading widely because of asymptotic people and it has arrived at lakhs in several influenced people and even a greater part of them are kicking the bucket, as a result of this pandemic malady. It is critical to lessen and control the spread of this illness because it does not show any symptoms (Rahman *et al.*, 2020). Asymptomatic people are very dangerous because they spread the disease without knowing and they can also have serious lung damage. Additionally, it is essential to distinguish the infected asymptotic people as quickly as time permits with the goal that they can be hospitalized for the early treatment and spare their life. To distinguish, detect and monitor the infected asymptotic people, we propose a system called detecting and monitoring the asymptotic patient.

In this paper, we have proposed a methodology for detecting and monitoring the asymptotic patient mainly to identify the infected asymptotic patient by collecting the information about them using IOT devices and also to monitor their health conditions after isolating them using the IoT devices. By applying this detecting and monitoring system, the proposed system supports the doctors and health-care professionals to identify and detect the asymptotic suspected case based on IOT, collect the information and provide them the treatment by isolating as early as possible. The spread of the disease can be reduced and patient life can be saved using this early detection mechanism. This system also extends its support to monitor their condition continuously after isolating them. In Section 2, the proposed methodology based on detecting the asymptotic patient and monitoring the asymptotic patients is explained. In Section 3, proposed design with the architecture of detecting and monitoring the asymptotic patient is reported. Section 4 describes the results and Section 5 presents the conclusion of this paper.

2. Proposed system

The proposed system detects the asymptotic patients, identifies them and their health condition, collects the information and passes it to the health-care professionals or doctors. Also, it transfers the information about whether they are having any infections through IoT devices or sensors. After the confirmation about the infectious disease, they might be isolated either at home or at hospital. If infected people are in home isolation, monitoring their health condition might be difficult for the health professionals. Hence, this paper also proposes a monitoring system to monitor the infected person's health conditions such as fever, blood pressure and heartbeat, collect all this above information and transmit to the health-care providers and doctors so that these doctors can analyse and provide the treatment. The monitoring of asymptotic patients is done by IoT-based devices such as sensors, actuators and software.

It is mandatory to detect the asymptotic patients as early as possible because these patients themselves will not know that they are affected and they might hugely spread the infection to others. Also, the asymptotic patients will be infectious and their oxygen blood saturation level will be less, they also will be affected by the serious lung damage in the later stage. Hence, detection of these types of patients is very important to protect them early from their infection and also from spreading the disease to others. After detecting and

confirming, these patients will be isolated. After this, it is also required to monitor their condition, if they are quarantined. So, our main goal of this proposed system is to mainly detect the disease, collect and send the information through IoT and internet devices such as mobile, personal computer (PC) and laptop. Also, monitor the patient after isolation, collect the information and transmit to the doctors through the IoT and internet devices such as mobile, PC and laptop.

2.1 Detecting the asymptotic patient

2.1.1 Raspberry Pi. The Raspberry Pi is a movement of charge card estimated single-board PCs made in Britain, the UK, by the Raspberry Pi Establishment with the reason to propel the teaching of crucial programming designing in schools and making countries. The main Raspberry Pi is shown in Figure 1 and Raspberry Pi 2 is created in a couple of board arrangements through approved amassing understanding with Network element14 (Premier Farnell), RS Parts and Eggman. The hardware is the same for overall creators. All Raspberry Pi's join a comparable Video Core IV designs Processing Unit (GPU), and either a singular community ARMv6CPU compatible CPU or a newer ARMv7 compatible quad-focus one (in Pi 2); and 1 GB of RAM (in Pi 2), 512 MB (in Pi 1 models B and B+), or 256 MB (in models An and A+, and the more prepared model B). They have a secure digital high capacity (SDHC) space (models An and B) or a micro SDHC one (shows A+, B+ and Pi 2) for boot media and steady amassing (Fizza and Nusrat, 2018). This Rasberry Pi will act as an interface for the sensors such as pulse oximeter and blood pressure. In our system, we use Rasberry Pi for detection with different sensors.

2.1.2 Global system for mobile communications. GSM is an abbreviation that represents the global system for mobile communications. Using cellular innovation, it can transmit versatile voice information (Figure 2). GSM has the arrangement for approaching active voice calls; it additionally can send instant message and information correspondence is done through general packet radio service (GPRS). The recurrence where this GSM works is from 850 MHz to 1,900 MHz. The GSM modem is a specialized gadget that associates the PC, portable and different gadgets to other electronic gadgets making a system (Sruthy *et al.*, 2017). In our system, the GSM is used to transfer the collected information through text messages to the doctors or health-care providers' mobile.

Figure 1.
Raspberry pi

Figure 2.
GSM

2.1.3 WiFi. The Raspberry Pi is ease, Visa estimated PC that connects to a PC screen or TV and uses a standard console and mouse. It is a competent little gadget that empowers individuals of any age to investigate registering and to figure out how to program in dialects such as Scratch and Python. The driving assortment of WiFi Raspberry Pi is shown in Figure 3, which is used to consequently interface with your WiFi organize you have to alter a record called: wpa_supplicant. conf. [. . .] Spare and close the document by squeezing Ctrl + X followed by Y. At this point, the Raspberry Pi should automatically connect to your network. This WiFi module is coordinated with Raspberry Pi. It has a transmission control protocol/internet protocol convention stack, which will offer access to the WiFi organize (María *et al.*, 2005). In our framework, this is used to send the data gathered from the different sensors to the specialists or doctors through the Webserver. In this way, the specialists or doctors can follow the data from their gadgets and give the treatment through WiFi.

2.1.4 Pulse oximeter sensors. A pulse oximeter is a non-invasive sensor that gives a nonstop estimation of blood vessel haemoglobin oxygen immersion just as the beat rate. These significant estimations illuminate the blood oxygenation and can be refreshed with each heartbeat as shown in Figure 4. The beat oximeter comprises a transductor, which uses two light-emitting diodes (LEDs) and a photodetector diode. One of the LEDs transmits red light (with a frequency of $\lambda = 660$ nm) while the other produces infrared light ($\lambda = 940$ nm). The sensor is in light of the way that the shade of blood fluctuates relying upon the oxygen it contains. Specifically, the haemoglobin atoms reflect progressively red light when they are oxygenated than when decreased while its conduct is the contrary when the light is infrared. The oximeter sparkles two light emissions through a finger (or ear cartilage and so on), which are at last detected by the photodetector. By looking at the light power (not reflected by the finger) for each frequency, the oximeter can infer the light that is being consumed by the blood and, subsequently, the oxygen immersion. Additionally, the pulse can be evaluated from the slight change in the shading incited by a beat of the heart pushing blood vessel blood into the finger. Customary heartbeat oximetry tests (as other conventional clinical sensors) are appended to the clinical screens by wires (Sudha *et al.*, 2018).

Figure 3.
WiFi

Figure 4.
Pulse oximeter with Raspberry pi

The COVID-19 patients are with regular side effects such as fever and cough, besides patients that are asymptotic show no signs or symptoms. It is obligatory to recognize that sort of patients ahead of schedule as conceivable to spare their lives and to quit spreading the infection to others and break the chain of spread to spare different lives too. Asymptotic patients are exceptionally risky and their infection can be distinguished by their oxygen levels in the blood; if it goes lower than typical, we can foresee that the specific patient is infected, when the oxygen level is lower than the given normal level, we say that one particular person is infected. To measure the blood oxygen saturation level, we use a pulse oximeter sensor. If the level is low, the samples are sent to the polymerase chain reaction (PCR) test.

2.1.5 Liquid crystal display. Figure 5 represents liquid crystal display (LCD), which is used to show both the information and the yield information. In our framework, LCD display is used to show temperature, oximeter measure and weight results. This LED display has 16 characters with 2 × 16 lines and shows this in two lines. It has 16 bundles and Arduino At mega 328 is associated with 8 information pins (Dhivya and Parameswaran, 2020).

2.2 Monitoring system after isolation

Monitoring patient health is most important after isolation if they tested positive. For this, we add sensors for the asymptotic patient monitoring system. The detailed discussion about the components is given further.

2.2.1 Temperature sensor. Thermopiles infrared temperature sensors permit to recognize exact temperature estimation from a separation without reaching. This is for the most part used in IoT clinical applications, the applications most ordinarily to detect the temperature by estimating ear, brow or skin temperature without physical contact. Figure 6 is shown at the point when the temperature is higher and more IR vitality is transmitted. This thermopile is made of detecting component, which has little thermocouples on a silicon chip; it likewise ingests vitality and gives a yield signal. A sensor that is planned into the bundle is referenced for return. These sensors are made of different focal points and channels. Here, we use the thermopiles infrared temperature sensor to identify the temperature of an individual (Banu Priya *et al.*, 2020). After isolation, it is mandatory to check the temperature frequently; using this temperature infrared sensor, temperature can be checked and the information can be gathered and transmitted to the doctors, so that when a person is in isolation doctor can receive the information without having any physical

Figure 5.
LCD

Figure 6.
Temperature sensor

contact. The authors have proposed a model for medical experts and public use which computes the recovery rate of COVID-19 patient which is independent of the age (Kumar *et al.*, 2020). The authors have analysed the social-economic inferences of coronavirus on the selected scopes. For tracing and observing the public, IoT devices and sensors were used (Prabhu *et al.*, 2020). The authors have implemented the IoT devices for preventing coronavirus and to track the affected patients' records (Josephine *et al.*, 2020). The electronic wearable devices were used by the authors for monitoring and sensing the symptoms of coronavirus (20).

2.2.2 Blood pressure sensor. It is obligatory to check whether the specific individual has expanded circulatory strain. A blood pressure sensor is used here to recognize the human circulatory strain (Figure 7). This sensor is made of piezoresistive innovation. Circulatory strain sensors are savvy sensors that recognize both systolic and diastolic estimations of pulse and beat perusing. Using the advanced circulatory strain sensors, which give versatility by evacuating a different simple to the computerized converter, the qualities are changed over to a simple electrical sign and afterward sent to the controller. Both hypotension and hypertension sicknesses are identified by this sensor (Dhivya and Parameswaran, 2020). Isolation blood pressure should be checked frequently, and using this blood pressure sensor, doctors will get the information through the internetwork connection of these sensors.

2.2.3 Heart beat sensor. The heartbeat sensor comprises a light-discharging diode and photodiode. The LED is put at the front side of the sensor. The finger has to be kept legitimately on the head of the LED. The LED produces the light that will befall the veins when the heart is siphoning. So heart thumps screen by the progression of blood. The received light is assessed after some time to decide heart pulsates. As shown in Figure 8, this heart beat sensor can work both at the +5 V or 3.3 V framework (Dhivya and Parameswaran, 2020). The heartbeat of the patient can also be monitored using the heartbeat sensor; this will collect the information about the patient in isolation and will send to the doctors or health-care professionals.

Figure 7.
Blood pressure sensor

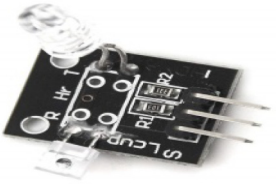

Figure 8.
Heartbeat sensor

3. Proposed architecture design of detecting and monitoring system

In our proposed detecting and monitoring system of COVID-19 asymptotic patient, we detect and identify the asymptotic patients of COVID-19 infected cases and send the gathered information through the sensors. Asymptotic patients of COVID-19 infection will not have any common symptoms of the disease. They will not know that they are infected with the disease until the infection becomes serious. Asymptotic patients can spread the disease to others without knowing that they are infected. Asymptotic patients can be detected by testing their blood saturation levels. If the blood saturation oxygen level is lower than the normal reading, then the patient is a suspected case of infection after testing this blood saturation level. For asymptotic patient, if the level is found to be lower, the sample of blood can be sent to PCR test for confirmation. Hence, to detect this blood–oxygen saturation level in our proposed detection system, we use pulse oximeter, IoT-based sensor, connected with the Rasberry Pi, where the oxygen level of the pulse oximeter is sensed from this sensor and it is transmitted to the doctors or health-care professionals through the mobile or laptop. So that after analysing, doctors may instruct the suspected case for PCR testing if the saturation level is low as shown in Figure 9.

In our proposed system, we also can monitor the asymptotic patient health condition if they are found to be infected and isolated, After the patient is quarantined, it is mandatory to check their health condition periodically. For even simple check-up, doctors have to go in person, but using our proposed system, doctors can monitor the patient's health condition using the IoT-based sensors. Mostly when people are in quarantine, doctors need to check the temperature, blood pressure and heartbeat. This can be monitored using the sensors without any physical contact. The temperature sensor senses the temperature of the patient whenever needed, a blood pressure sensor will sense the pressure level of the patient and a heartbeat sensor will sense the heartbeat rate of the patient. All the gathered information will be sent to the doctors or health-care professionals through mobile or laptop using a GSM or WiFi module, so

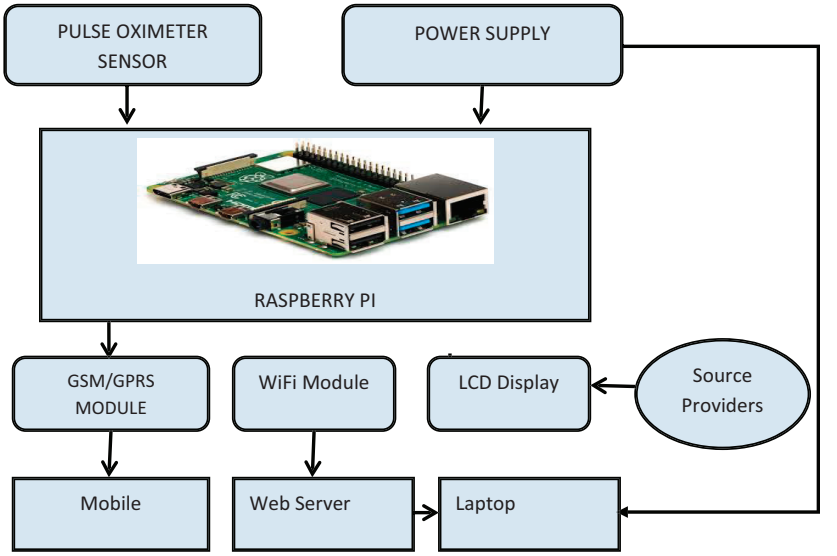

Figure 9.
Detection system of asymptotic patient

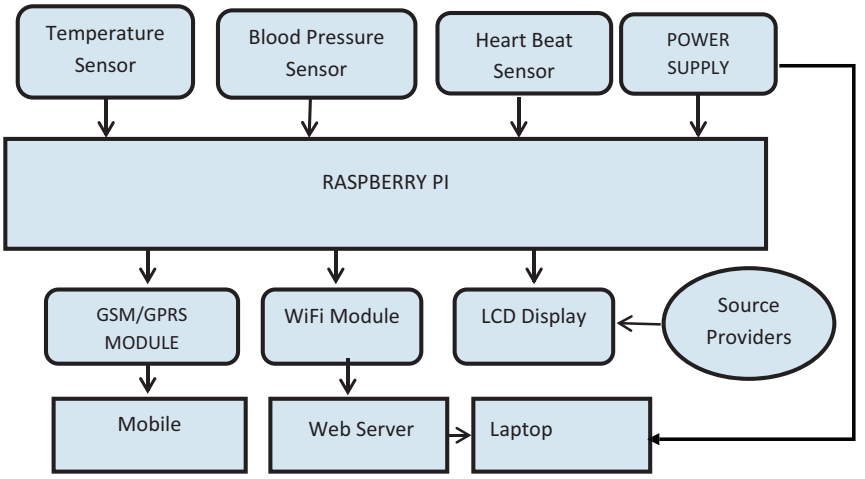

Figure 10.
Monitoring system of asymptotic patient

that doctors can monitor the health condition of the patient periodically and can provide the treatment. The proposed monitoring design of monitoring the asymptotic patients is shown in Figure 10.

The parameters for the monitoring system are predetermined and the results, which are taken from the sensors, are combined with predetermined values. The temperature, blood pressure and heartbeat rate have their predetermined values. If the values, which are sensed, are different from the predetermined values, then the abnormal values will be sent to the doctors and values will be shown in LCD. The patient details will be monitored and stored on the Web server; from the Webserver, the alert and collected detailed information can be sent through a WiFi network module to their laptop or desktop.

4. Result

By expending our proposed system, the infected asymptotic patients can be detected by the reading of the pulse oximeter, which is sensed by the pulse oximeter sensor. If the patient's oxygen saturation level is lower than the predetermined values then it will be shown in the LCD screen and gathered data will be sent to the doctors.

Normal pulse oximeter reading is usually between 95% to 100%, which is predetermined and the values, which are below 90% are considered low. When the oxygen saturation level collected from the pulse oximeter sensor reading is lesser than 90, then we suspect that the patient might be affected by the COVID-19 as shown in Figure 11, which is displayed on the LCD screen. These patients will be sent to PCR testing and if the test is confirmed with

Figure 11.
Pulse oximetry values with LCD display

the disease, then the patient will be isolated at either home or hospital. By using our proposed system, we also can monitor the patient's health condition when the infection-confirmed patient is quarantined. Temperature, blood pressure and heartbeat rate can be monitored using the IoT-based monitoring system. The normal body temperature is 98.6°F or (37°C) and it is predetermined. Frequent monitoring of the temperature of a patient is done through the temperature sensor and if the temperature is higher than normal, which is displayed on LCD, then it is sent through the network to doctors, which will be helpful to give treatment accordingly. Likewise, the normal blood pressure is 120 over 80 mm of mercury (mmHg). The blood pressure and heartbeat rate can also be monitored using the sensors. If any changes found by the doctors in the patient's heartbeat and blood pressure through sensors, treatment can be given immediately. These values of heartbeat and blood pressure whenever needed are taken and sent to the doctors, which will also be shown in the LCD as shown in Figure 12. Hence, the detection of the asymptotic patient and monitoring is done through our proposed system.

5. Conclusion

By disbursing our proposed IOT-based detection and monitoring system for the asymptotic COVID-19 patients, the doctors and the health-care professionals will be able to detect the asymptotic patients and analyse the disease as early as possible by collecting the pulse oximeter readings whether it is low or high or normal. Since asymptotic patients will not have any symptoms, we can identify through our proposed system and the samples will be sent for PCR testing if doctors found that the level of oxygen is low through our system. So early detection will help the patient to save their lives and also of others by breaking the chain and stopping the spread of this contagious disease. Using IoT, the system detects the asymptotic patient to save their life and break the chain. This system includes IOT-based detection using the oximeter sensors. Our system is not only used for detecting the asymptotic patients but also doctors will be able to monitor their health condition when the asymptotic patients are being quarantined. Temperature, blood pressure and heartbeat rates are also monitored when the patients are in quarantine. The temperature is monitored by collecting the temperature frequently using the temperature infrared sensors by sensing the temperature from the forehead or skin temperature reading where doctors need not have physical contact; these collected readings will be sent to the doctor's mobile or laptop through a Web server. Likewise, blood pressure data are collected by the blood pressure sensor frequently and sent to the doctor's mobile or laptop through the Webserver. Blood pressure is monitored frequently by using our system. Heartbeat rate can also be monitored by collecting the data rate of the heart using the heartbeat sensor. This sensor senses the data and sends it to the doctors frequently so that doctors will be able to monitor them and provide the treatment. Doctors can collect the details of asymptotic patients early and isolate them. Doctors can also monitor their health conditions when the patient is isolated to give early treatment and to save their lives. In

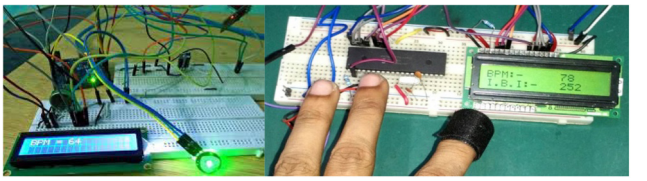

Figure 12.
Temperature and blood pressure values with LCD display

future work, the paper can be extended to get the clinical data for the detection and diagnosis of the disease.

References

Banu Priya, K., Rajendran, P., Kumar, M.S., Prabhu, J., Sukumar, R., Kumar, P.J., Thanapal, P., Christopher, J. and Jothikumar, R. (2020), "Pediatric and geriatric immunity network mobile computational model for COVID-19", *International Journal of Pervasive Computing and Communications*, Vol. 16 No. 4, doi: 10.1108/IJPCC-06-2020-0054.

Chamola1, V., Hassija, V., Gupta, V. and Guizani, M. (2020), "A comprehensive review of the COVID-19 pandemic and the role of IoT, drones, AI, blockchain and 5G in managing its impact", *IEEE Access*, Vol. 8, doi: 10.1109/ACCESS.2020.2992341.

Dhivya, M. and Parameswaran, T. (2020), "Smart scheduling on the cloud for IoT-based sprinkler irrigation", *International Journal of Pervasive Computing and Communications*, ISSN: 1742-7371, doi: 10.1108/IJPCC-03-2020-0013.

Fizza, H.*1. and Nusrat, H.S. (2018), "Wireless notice board based on Arduino and gsm technology", *International Journal of Engineering Sciences and Research Technology*, ISSN: 2277-9655.

Gurjar, A.A., Dr. and Sarnaik, N.A. (2018), "Heart attack detection by heartbeat sensing using internet of Things: IoT", *International Research Journal of Engineering and Technology (IRJET)*, Vol. 5 No. 3, ISSN: 2395-0072.

Hegde, S. and Mundada, M.R. (2020), "Early prediction of chronic disease using an efficient machine learning algorithm through adaptive probabilistic divergence-based feature selection approach", *International Journal of Pervasive Computing and Communications*, ISSN: 1742-7371, doi: 10.1108/IJPCC-04-2020-0018.

Josephine, M.S., Lakshmanan, L., Nair, R.R., Visu, P., Ganesan, R. and Jothikumar, R. (2020), "Monitoring and sensing COVID-19 symptoms as a precaution using electronic wearable devices", *International Journal of Pervasive Computing and Communications*, Vol. 16 No. 4, doi: 10.1108/IJPCC-06-2020-0067.

Krishna, C.S. and Sampath, N. (2017), "Healthcare monitoring system based on IoT", *2nd IEEE International Conference on Computational Systems and Information Technology for Sustainable Solutions,978-1-5386-2044-1/17/$31.00 ©2017 IEEE.*

Kumar, M.S., Maheshwari, V., Prabhu, J., Prasanna, M., Jayalakshmi, P., Suganya, P., Benjula Anbu Malar, M.B. and Jothikumar, R. (2020), "Social economic impact of COVID-19 outbreak in India", *International Journal of Pervasive Computing and Communications*, Vol. 16 No. 4, doi: 10.1108/IJPCC-06-2020-0053.

María, J.M., Casilari, E., Luque, R. and Gázquez, J.A. (2005), "A wireless monitoring system for pulse-oximetry sensors", Research gate, doi: 10.1109/ICW.2005.20 • Source: IEEE Xplore.

Prabhu, J., Kumar, P.J., Manivannan, S.S., Rajendran, S., Kumar, K.R., Susi, S. and Jothikumar, R. (2020), "IoT role in prevention of COVID-19 and health care workforces behavioural intention in India-an empirical examination", *International Journal of Pervasive Computing and Communications*, Vol. 16 No. 4, doi: 10.1108/IJPCC-06-2020-0056.

Rahman, M.S. Peeri, N.C. Shrestha, N. Zaki, R. Haque, U. and Ab Hamid, S. (2020), "Defending against the novel coronavirus (COVID-19) outbreak: How can the internet ofThings (IoT) help to save the world?", doi: 10.1016/j.hlpt.2020.04.005.

Ramadass, L., Arunachalam, S. and Sagayasree, Z. (2020), "Applying deep learning algorithm to maintain social distance in a public place through drone technology", *International Journal of Pervasive Computing and Communications*, Vol. 16 No. 3, doi: 10.1108/IJPCC-05-2020-0046, ISSN: 1742-7371.

Reddy, E.R. and Sankara, K. (2018), "Internet of things based home automation control system using raspberry Pi", *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, Vol. 3 No. 4, ISSN: 2456-3307.

Saranya, E. and Maheswaran, T. (2019), "IOT based disease prediction and diagnosis system for healthcare", *International Journal of Engineering Development and Research*, Vol. 7 No. 2, ISSN: 2321-9939.

Shirode, M., Adaling, M., Biradar, J. and Trupti, M. (2018), "IOT based water quality monitoring system", *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, Vol. 3 No. 1, ISSN: 2456-3307.

Sruthy, S. and Sudhish, N.G. (2017), "WiFi enabled home security surveillance systemusing raspberry Pi and IoT module", *IEEE SPICES,978-1-5386-3864-4/17/$31.00 © 2017*, IEEE.

Sudha, S., Dr., Shruthi, P. and Sharanya, M. (2018), "IoT based measurement of body temperature using max30205", *International Research Journal of Engineering and Technology (IRJET)*, Vol. 5 No. 3.

Yang, Y., Wu, L., Yin, G., Li, L. and Zhao, H. (2016), "A survey on security and privacy issues in Internet-of-Things", *IEEE INTERNET of THINGS Journal*, Vol. 4 No. 5, ISSN: 2327-4662 (c) 2016 IEEE.

Further reading

Sinha, A. (2020), "Study on IoT (internet of things) and its applications", *International Journal for Research in Applied Science and Engineering Technology*, Vol. 8 No. 6, ISSN: 2321-9653.

Corresponding author

Rajeesh Kumar N.V. can be contacted at: rajeesh555@gmail.com