Design and development of an IoT based intelligent multi parameter screening system

P. Arun *, N. Prajith, C. Melvin, S.N. Sreejith, S. Sandesh

Department of Electronics and Communication Engineering, St. Joseph's College of Engineering and Technology, Palai 686 579, India

ARTICLE INFO

ABSTRACT

The SARS-CoV-2 or shortly COVID-19, is a viral disease which causes serious lung fever and hugely impacts different body parts from mild to critical depending on tolerant immune system. As the virus multiplies through human-to-human contact, it has affected our lives in a devastating way, including the vigorous pressure on the public health system, the world economy, education sector, workplaces, and shopping malls. Viral spreading of this virus can only be prevented by early detection of positive cases and to treat infected patients as quickly as possible. As many businesses, banks, gymnasiums, and stores etc., are using temperature screening as the primary step to assess for possible COVID-19 infection. Moreover, the proper hand sanitization is the very effective method to limit the outspread of this virus. This paper proposes the design and development of a fully automated low-cost portable electronic system in the form of a robot named CovBot that can be installed in the above-mentioned places by incorporating the mechanisms to automatically detect the body temperature, store the details directly to cloud so as to get the data latter by the authorities, to control/restrict the entry, a hand sanitization dispenser unit, auto alert to refill the sanitizer, a mobile display unit etc. Whole system can be managed by a mobile application. The system is controlled using an Arduino-Uno development board. The mobile and the microcontroller system is wirelessly communicated and that to cloud is done by IoT facility. Once this system is implemented, the primary concern and the initial screening associated to COVID-19 can be fully resolved. Comparing to other systems CovBot is cost effective and can be easily installed and operated.
Copyright © 2022 Elsevier Ltd. All rights reserved.
Selection and peer-review under responsibility of the scientific committee of the International Conference on Artificial Intelligence & Energy Systems

1. Introduction

The studies revealed [1–3] that COVID-19 is an infectious disease caused by the recently discovered coronavirus spreads mainly through droplets of saliva or runny nose when an infected person coughs or sneezes, turning it in a highly infectious disease, because of that, these low-cost robots can provide alternatives in the combat of this disease that do not require contact between the sick people and the healthy people. Mobile robotics has nowadays made many advances and this knowledge is applied in carrying out various tasks; the flexibility in programming these devices allow us to create new applications without the requirement to make new designs, that is, it allows us to readapt the designs to current needs. With the proper usage of these systems the spread of the disease can be reduced by not having human–human but human–machine interaction.

The global impact of COVID-19 pandemic has led to a rapid development and utilization of mobile health applications including contact tracing, health information dissemination, symptom checking and providing tools for the support of healthcare providers. This section of the paper focuses to create a sense of acknowledgement among people to what extent temperature sensing can be beneficial in Covid cases, use of IOT based system for screening purpose and maintaining social distancing, how mobile applications will help us fight against Covid 19, related research work has also been discussed.

BBC news [4] reported that a high temperature is usually considered to be 38 °C or over. But normal temperature can differ from one person to another and change during the day. Other symptoms include a high temperature or fever. Others include nausea, headaches, fatigue and loss of taste or smell. But not everyone affected with the virus gets a high temperature and not everyone with a

* Corresponding author.
   E-mail address: arun@sjcetpalai.ac.in (P. Arun).

high temperature is infected with coronavirus. As states and communities implement reopening public places during the COVID-19 pandemic, non-contact temperature sensing devices may be used as part of an initial check at entry points to identify and scan people who may have elevated temperatures. Thermal imaging systems and non-contact infrared thermometers, which are non-contact temperature assessment devices, may be used to measure a person's temperature. A high temperature is one of the methods to identify a person who may have a COVID-19 infection, although an infected person without an elevated temperature may be contagious to COVID virus.

Karmore et al. [5] proposed that the IoT revolution reshapes modern healthcare systems and incorporates technological, economic, and social prospects. It evolves healthcare systems from conventional to much more personalized healthcare systems through which diagnosis of patients could be done more easily. With reference to COVID-19, IoT-enabled/linked devices/applications were utilized to lower the possible spread of COVID-19 to others by early diagnosis and monitoring of patients through defined protocols after the patient is fully recovered. IoT devices could speed up the detection process by capturing information from patients. This information includes body temperatures, samples from suspicious cases, etc.

During the first wave of COVID-19, various mobile health (mHealth) apps were rapidly developed in order to tackle the virus. Few articles [6–8] reported that the first COVID-19 apps that were developed and widely publicized were based on contact tracing, which were created to notify its 'users if they had interacted with another person infected with the coronavirus. The first national app was developed in Singapore, which used Bluetooth technology for contact tracing. If someone was in close contact with an infected individual, the app would notify through a push notification to alert them of possible COVID-19 infection and further suggest that they undergo testing. This technology was made open source and was shared internationally for other countries to build similar apps for their own people. Based on that a Government of India initiative, Arogya Setu was designed to assist citizens to help them find if they had been in contact with an infected person. The app uses GPS and Bluetooth on a smartphone to create a social graph. Based on that, it concluded if a symptomatic person had crossed path with someone who has been infected with covid-19.

2. Literature review

A few researches have been carried out in this area to discuss the technologies as well as the implementation details. The aim of the present study is to discuss the various aspects of modern technology used to fight against COVID-19 crisis at different scales.

Cardona et al. [9] done an investigation on the different applications of mobile robots used against the Covid19 pandemic. It showcased the different contributions of companies around the world that seek to adapt to the new needs in order to be able to mitigate the progress of the Covid-19 using mobile robots as a tool, focusing primarily in the area of health and service. Biswas et al. [10] proposed a robot which automatically follows the doctor (maintaining an appropriate distance), through the array of some distance measuring sensors and follow the instructions of their instructor (doctor). It also has automatic sanitization capability which helps in performing touch-less operation. It has UV sterilization system for cleansing of essential equipment's of doctors.

Akhund et al. [11] suggested an IoT based robotic agent specially designed for disabled and Covid-19 affected people. This was able to recognize the patient's gesture and follow instructions through it with 360-degree movement. This was used MPU 6050 Accelerometer Gyroscope sensor for Gesture Recognition. Radio

Frequency communication was used to make the system wireless. Edelstein et al. [12] investigated that equitable sharing of public health surveillance data which could further mitigate the effect of infectious diseases. Healthcare professionals were traditionally mandated to notify public health authorities about cases of specified diseases within a certain timeframe. Afterwards the authorities analyze the data and take appropriate actions. Surveillance systems therefore tend to be the responsibility of the government.

Menni et al. [13] provided a real-time tracking of self-reported symptoms to predict potential Covid-19, from their study it was clear that a total of 2,618,862 participants reported their potential symptoms of COVID-19 virus on a smartphone-based app. Among the 18,401 who had undergone a SARS-CoV-2 test, the proportion of participants who reported loss of smell and taste was higher in those with a positive test result (4,668 of 7,178 individuals; 65.03%) than in those with a negative test result (2,436 of 11,223 participants; 21.71%) (odds ratio = 6.74; 95% confidence interval = 6.31–7.21). From these outcomes they developed a model combining symptoms to predict probable infection which was further applied to the data from all app users who reported symptoms (805,753) and thus it predicted that 140,312 (17.42%) participants are likely to have COVID-19. Qin et al. [14] proposed how artificial intelligence can be enabled for rapid diagnosis of Covid-19 among the patients. Mei et al. [15] used AI algorithms that integrated chest CT findings with clinical symptoms, exposure history and laboratory testing to rapidly diagnose patients who were positive for COVID-19. The AI system also improved the detection of patients who were positive for COVID-19 via RT–PCR who were presented with normal CT scans, correctly identifying 17 of 25 (68%) patients. When CT scans and associated clinical history were available, the proposed AI system could help to rapidly diagnose COVID-19 patients.

Wang et al. [16] provided introduced deep learning algorithm using CT images that can be used to screen Corona virus disease. Based on COVID-19 radio graphical changes in CT images, they figured out that AI deep learning methods might be able to extract COVID-19′s specific graphical features thus, provide a clinical diagnosis ahead of the pathogenic test, thus saving critical time for disease control. Vincent et al. [17] proposed a brief idea about the robotic applications during a pandemic and to identify future research trends have been given in [9]. Kraemer et al. [18] discussed effect of human mobility and control measures on the COVID-19 epidemic in China, they used real-time mobility data from Wuhan and detailed case data including travel history to elucidate the role of case importation in transmission in cities across China and to ascertain the impact of control measures.

Lampos et al. [19] used time series of online search query frequencies to gain insights about the prevalence of COVID-19 in multiple countries. The information about how different sources of data were compared to each other were provided in the article [20]. In some cases, the metrics correlate well, but not all. Sandford Medicine Scientist [21] used data from wearable devices to predict illness including Covid 19. They collaborated with Fitbit and Scripps research to launch a new effort that aims to detect early signs of viral infection through data from smartwatches and other wearables. Ministry endorsed an app called HaMagen Health [7] to tell who have been in the presence of anyone who has been diagnosed with coronavirus. Government of India developed an app called Aarogya Setu [8] which is based on contact tracing, syndromic mapping and self-assessment" digital service developed by National Informatics Centre under the Ministry of Electronics and Information Technology.

By the initiative of World health organization [22] a secure, decentralized, privacy-preserving proximity tracing system have been developed with a goal to simplify and accelerate the process to identify people who have been in contact with an infected per-

son. The process of sending SOS alerts through google has been given in [23]. SOS Alerts aim to make emergency information more accessible during a crisis. IIT Guwahati in collaboration with Workspace Metal Solutions Private Limited, Udaipur, had developed [24] a self-check kiosk. This small structure helped by streamlining flow of people through the kiosk. The Kiosk only takes about 30 s to check whether the person is safe to enter the premises or not. It performs an accurate contactless check which could determine if an individual is running a fever, low blood oxygen levels and, therefore, potentially has COVID-19 or any other viral or bacterial infection.

IIT Bombay pass outs had developed a thermal scanning kiosk [25] with facial recognition to tackle Covid-19. Arvi kiosks used AI technology with deep learning to combine facial recognition and thermal screening to detect persons with high temperatures. The thermal scanning kiosks has features such as temperature check, face mask detection, auto hand-sanitization, and attendance/access management.

Most of the proposed system are comparatively priced at much higher amount. Also, the self-check kiosk developed by IIT Guwahati is truly on of its kind but has a major disadvantage that it fails to address the ground reality, most of the locals find it difficult to install the self-check kiosk, it also lacks in the area of sanitization. There is no automatic hand sanitizer incorporated it. Apart from this the UV-C radiations used as a disinfectant in one of the proposed systems can effectively kill the SARS-COV 2 coronavirus but these lamps used for disinfection purposes may pose potential health and safety risks depending on the UVC wavelength, dose, and duration of radiation exposure. Another proposed system used a MPU 6050 Accelerometer Gyroscope sensor for Gesture Recognition along with an Arduino Nano, the only disadvantage in this system is that as small gestures given to the sensor piles up it accumulates error which give rise to noise which has to further filtered. Another major lacuna drawn is that most of the proposed system used complex hardware and software network thus it becomes difficult for the locals using this system to operate it at their own will. Maintaining social distancing inside an organization along with proper screening is also one of the major disadvantages. Also, majority of the systems available currently installed without prior testing.

The design and development of a multifunctional low-cost portable electronic system called CovBot is proposed in this paper. The features of the systems are it is capable to automatically detect the body temperature, store the details of the customers directly to cloud so as to get the data latter by the authorities, to control/restrict the entry, a hand sanitization dispenser unit, auto alert to refill the sanitizer, a mobile display unit etc. Prior to develop the prototype, the whole system has been successfully simulated with a virtual simulator. The main hardware system can be remotely operated by a mobile application. The microcontroller platform of the proposed system is based on Atmega-328 Arduino Uno development board. Once this system is implemented, the primary concern and the initial screening associated to COVID-19 can be fully resolved.

The rest of the paper is organized as follows Section 3 describes, the system model and methodology. The results and related discussion have been presented in Section 4 followed by the conclusions and future works.

3. Methodology and system design

The circuit diagram and the simulation of the multifunctional screening system is done in Dip trace and Proteus software respectively. As already stated, a mobile application is used to remotely control all the main hardware system and it is developed by MIT app inventor. The microcontroller programming of the development board is done in Arduino IDE. The 3-D modelling of the enclosure is developed in Sketchup software. The detailed block diagram of the proposed system is shown in Fig. 1. CovBot consists of 7 main blocks: Control Block or the processing unit, Temperature sensor, Bluetooth module, an android device, Sanitizer dispenser, Object detection sensor and the Power supply.

The control block regulates and integrates all the operations. Temperature sensor calibrates the temperature of the customers. Bluetooth modules is used for serial communication between control block and the android device. The android device acts as an interface for the customers to interact. Object detection sensor senses object standing in front of the CovBot. The power supply is given to power up the load. The system is divided into input and output sections. Power is supplied through a 9 V adapter which is directly connected to the Arduino. This 9 V is further bucked into 5 V with a maximum current of 2A, which is fed an input to other sensors and components. Provisionally in the block diagram there is a direct connection between the Arduino and solenoid valve, but practically they cannot be connected directly as the solenoid valve uses high voltage (6 to 12 V) and sometimes the Arduino cannot handle these high values, thus we need a middle device to accept the 5 V from Arduino as control signal and handle high voltage and current required to the valve. This middle device consists of transistor, diode and resistors. The peripherals which are enclosed inside a single dotted box consists of a single system. Two servo motors, and both the ultrasonic sensors are connected over the entry and exit door. The servo motors rotate according to the control signal received from the microcontroller. The microcontroller sends the pulse to the motor on the basis of the temperature value. Based on the pulse received from the ultrasonic sensors the count is incremented and decremented. The dotted arrows are used to represent wireless connections between the Bluetooth module and the android device with the cloud.

The circuit diagram of the CovBot is shown in Fig. 2. This circuit consist of a 28 pin, 8-bit microcontroller embedded on an Atmega-328 Arduino Uno development board, three ultrasonic sensors which emits ultrasound at 40 KHz which travels through the air and if in the presence of any object or obstacle on its path it bounces back to the module. A PIR sensor is also fitted which acts as an object detection sensor, when a warm body passes by it intercepts one half of the PIR sensor, which causes a positive differential change between the two half and when the body leaves the reverse happens. These change in pulses are what is detected. The HC-SR04 Ultrasonic Module has 4 pins, Ground, VCC, Trig and Echo. The
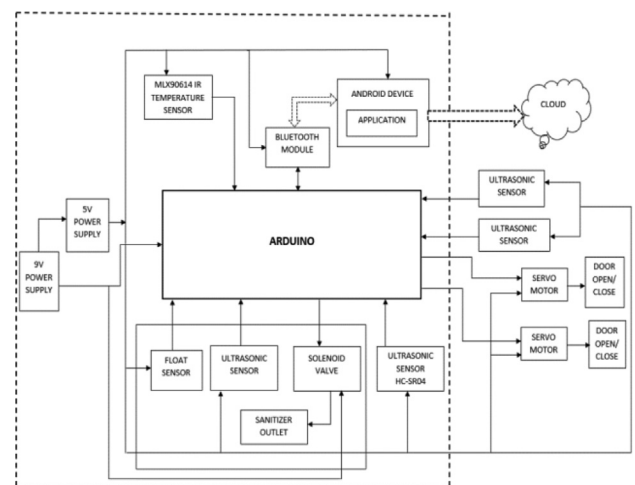

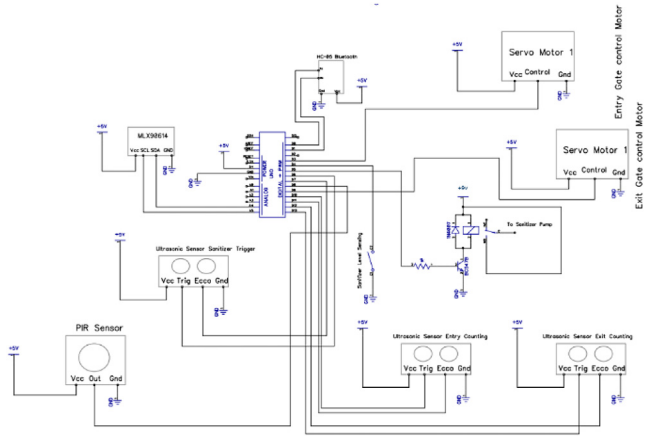**Fig. 1.** Block Schematic of the CovBot.

Fig. 2. Circuit Diagram of CovBot.

Ground and the VCC pins of the module needs to be connected to the Ground and the 5 V pins on the Arduino Board respectively and the trig and echo pins to any Digital I/O pin on the Arduino Board. The Bluetooth module HC-05 uses serial communication to communicate with the electronics.

The step-by-step process flow of the complete system is given below.

STEP 1: Start the robot by turning on the power supply.

STEP 2: Initialize the hardware components and other sensors.

STEP 3: Take voice input of the phone number and name via google assistant incorporated in the application.

STEP 4: The Bluetooth module (HC05) communicates serially with Atmega-328 with a baud rate of 9600.

STEP 5: Phone number and name is displayed on the smartphone display.

STEP 6: Temperature is calibrated with the help of MLX90614 contact less sensor.

STEP 7: Temperature is displayed on the smartphone display.

STEP 8: Temperature, name and phone number are stored in the cloud through the application.

STEP 9: Temperature is checked with the threshold value.

STEP 10: If it is greater than the threshold, then the door remains closed.

STEP 11: If it less than the threshold value, the door opens.

STEP 12: The IR sensor activates and the counter takes count of the incoming signal.

STEP 13: Controller checks the count value.

STEP 14: If the count is less than 5, counter increments and the door open. Then go to STEP 3.

STEP 15: If the count is equal to 5, a 'please wait' message is displayed.

STEP 16: Based on the pulse from Atmeag-328, it checks whether the servo motor rotates.

STEP 17: If the motor doesn't rotate, go to STEP 15,

STEP 18: If the motor rotates, the exit door opens.

STEP 19: The counter decrements. Then go to STEP 12.

STEP 20: Finally, the exit door closes.

Casings determine the final size and shape of the product. The primary purpose of enclosure is to protect its contents from any damage. Enclosure has many different roles. These include providing protection, safety, enhanced usability, attractive looks, optimal design and specific customer requirements, etc. The enclosure design is done in Sketchup software. The various views of the casing are provided in Fig. 3. (Various views).

4. Result and discussion

This session describes the results obtained at various stages of this work. The main phases of the design and development of this system are – Simulation of the whole design, Output of the Android Application and the Prototyping.

Fig. 4 (a) shows the screenshot of the android application developed to take name, phone number and display the calibrated temperature. After the name and number are fed as voice input, they are stored in the cloud as text format. Apart from this, the app also takes people count inside the installed area and also checks the sanitizer level. If the level is below the threshold value a 'low level' message is displayed.

Just press the input button to input the voice via google assistant. When the name and number are correctly displayed, press the store button to store the information in the cloud. Whenever the ultrasonic sensor detects an external body in front of the robot "Please sanitize your hand then press input button and say your name and phone number" audio message is delivered. The details of information sent to cloud is given in Fig. 4(b). The cloud results show the information fed via voice through the mobile application. It consists of name, phone number, temperature, and also the time when this information was fed. Further modifications are to be done to improve the user interface of cloud. Successful simulations of different sections of the CovBot are done in Proteus real time virtual simulator and is considered as one of the major highlights. The screenshot of the automatic hand sanitizer is presented in Fig. 5(a) and that of the counter with temperature calibration is presented in Fig. 5(b).

The servo motor rotates whenever one's hand comes near to the ultrasonic sensor (the distance can be specified in the code). In the simulation, as the potentiometer attached to the ultrasonic sensor varies the distance measured also varies. For the time being a switch is connected with the ultrasonic sensor, which acts as a pulse for the sensor. When the switch is closed, connection is established and the motor rotates thus the liquid comes out. In the virtual terminal it is seen that the initial count is 0 then it increments to 1. The same 1 persist until another person enters the store to make the count to 2. Further this 2 continues until the 3rd person enters and so on. If the value in the entrance potentiometer is less than the exit potentiometer the count increments, else it decrements. If the values are same then the count continues with the same value.

The images of the prototype of the CovBot at various views are presented in Fig. 6. (a-b). The designed wall mounted robot senses the presence of an external body with the help of an ultrasonic sensor (HCSR04) which sends a transmitting pulse at a frequency of 40KHz and receives an echo. After the presence has been detected the mobile application developed, takes voice input of the phone number and name of the customer and calibrates the temperature with the help of a non-contact temperature sensor (MLX90614). The temperature and the phone number are shown on the display of the mobile phone placed on the robot. According to the fixed threshold temperature the operation of the entry and the exit door of shops, hospitals, schools etc can be controlled. The counters placed over the entry and exit doors also help in taking count of the people present inside the above listed places. Apart from all these an automatic hand sanitizer dispenser is also incorporated in this proposed system which further contributes in the disinfection process and maintains a healthy environment.

A comparative study has been performed by considering the existing systems. The details are presented in Table 1. The table compares various existing technology with the proposed system on the basis of user interactions, type of microcontroller used, sensors incorporated, sanitization facility and cost. This study on var-
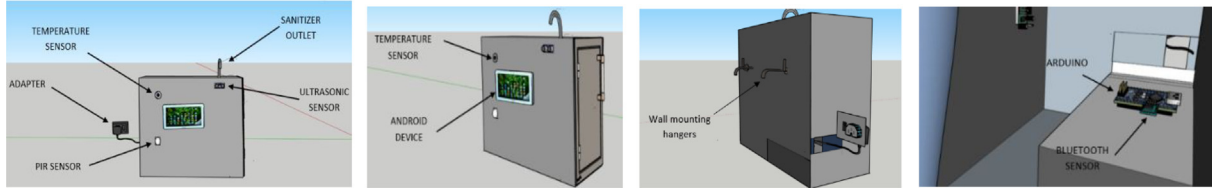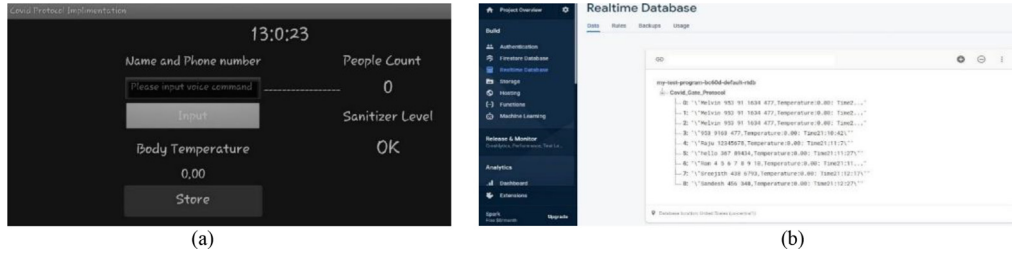
Fig. 3. Enclosure design- various views.

(a)   (b)

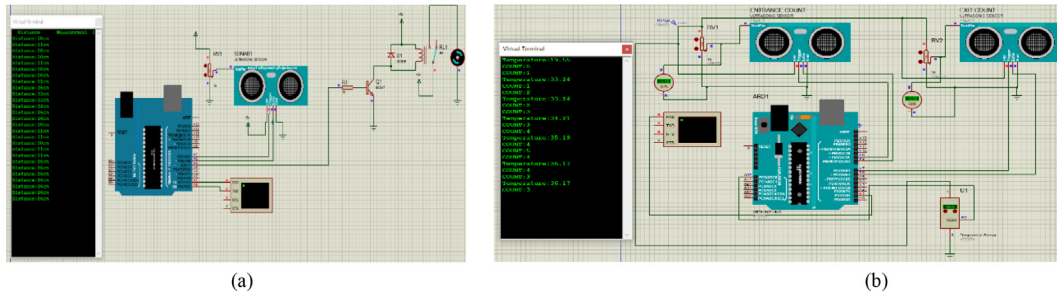**Fig. 4.** Screenshot of (a) Covid Protocol Implementation app and (b) Cloud results.

(a)   (b)

Fig. 5. Screenshot of the working of (a) automatic hand sanitizer (b) automatic hand sanitizer.

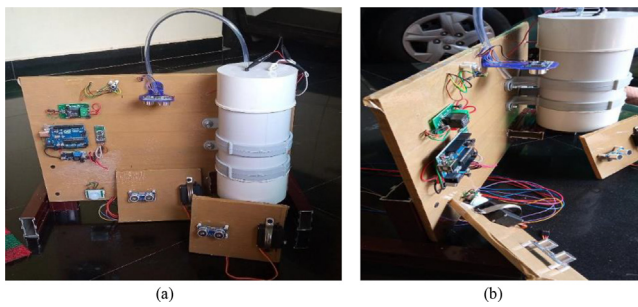(a)   (b)

Fig. 6. Prototype of the CovBot (a) front view; (b) side view.

ious existing technologies is completely on the basis of the references stated in the table. The major advantage of this proposed system against other systems is the cost. All the other systems are priced at a value much higher than the local vendors and shopkeepers can afford. Thus, it can be incorporated in various public places like gyms, local street shops, banks etc. as these places have a major contribution for the rise Covid cases across the region. Once this pandemic end, the CovBot can also be used as a surveillance system by maintaining a database of people and keeping their count by incorporating it in the above-mentioned places.

Table 1
Comparison with existing works.

Reference	User Interaction	Microcontroller Platform	Sensor Used	SanitizationFacility	Cost (Rs)
9	Gesture	Arduino Nano	MP6050 Gyroscope	No	30,000
10	Touchless	Details not available in literature	SPo2 sensor	Yes	3.3–7 lakh
20	Face recognition	Details not available in literature	Infrared, pulse oximeter, capnometers	Yes	60,000 – 1.25 lakh
24	Autonomous (touchless)	Arduino	IR and voltage sensors	No	30,000
25	Autonomous	Raspberry Pi	IR, airflow, E health sensor kit, galvanic skin response sensor	Yes	50,000
Proposed System	Via Voice	ATMega - 328	Ultrasonic, MLX90614, IR, Level sensor	Yes	11,000

5. Conclusion

The COVID-19 pandemic confirmed not only the need for data sharing but also the need for rigorous evaluation and ethical frameworks with community participation to evolve alongside the emerging field of mobile and digital healthcare. Building public trust through strong communication strategies across all digital channels and demonstrating a commitment to proportionate privacy becomes imperative. The future of public health is likely to be increasingly digital, thus recognizing the importance of digital technology in this field and in pandemic preparedness becomes urgent. This paper depicted the design and development of an IoT based low-cost multifunctional wall mounted device. Unlike other systems, this resolves the initial screening process in areas where comparatively expensive system cannot reach. This work resulted in a fully automated cost effective portable electronic system in the form of a robot named CovBot that can be installed in the places such as banks, gymnasiums, and stores etc. This system was developed by incorporating the mechanisms to automatically detect the body temperature, to store the details of the customers directly to cloud so as to get the data latter by the authorities, to control/restrict the entry, a hand sanitization dispenser unit, auto alert to refill the sanitizer, a mobile display unit etc. Whole system was fully controlled by a mobile application. Thus, the healthcare officials get real time data based on the information provided by the people. The information provided may be inaccurate but considering an ethical scenario and taking Covid as a cause of concern it is the responsibility of every being to provide veracious data and provide a helping hand in this fight against Covid-19 virus.

As a future deviation, features like pulse monitor, a camera surveillance, UV-C disinfection, Blood oxygen saturation can be incorporated to this system. The new gen trending biological sensors can also be integrated to check the real time health monitoring. As a feature enhancement, the machine learning and AI capabilities can be added to this robot.

CRediT authorship contribution statement

P. Arun: Supervision, Writing – original draft. **N. Prajith:** Data curation. **C. Melvin:** Conceptualization, Methodology. **S.N. Sreejith:** Resources, Investigation. **S. Sandesh:** Data curation, Writing – original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] K. Sun, J. Chen, C. Viboud, Early epidemiological analysis of the coronavirus disease 2019 outbreak based on crowdsourced data: a population-level observational study, Lancet Digit Health 2 (2020) 201–208.

[2] K. Gostic, A.C.R. Gomez, R.O. Mummah, A.J. Kucharski, J.O. Lloyd-Smith, Estimated effectiveness of symptom and risk screening to prevent the spread of COVID-19, eLife 25 (13) (2020) 1–18.

[3] B.J. Quilty, S. Cliford, S. Flasche, R.M. Eggo, Efectiveness of airport screening at detecting travelers infected with novel coronavirus (2019-nCoV), Eur. Surveill. 25 (5) (2020) 1–6.

[4] Online, [Available], https://www.therobotreport.com/uvd-robots-responds-surging-demand-during-covid-19-crisis/ (2020).

[5] S. Karmore, R. Bodhe, F. Al-Turjman, R.L. Kumar, S. Pillai, IoT Based Humanoid Software for Identification and Diagnosis of Covid-19 Suspects, IEEE Sens. J. 5 (2020) 1–9.

[6] J.L. Singh, Hanson, Mobile Health Apps That Help With COVID-19 Management: Scoping Review, JMIR Nursing 3 (1) (2020) 1–8.

[7] Online, [Available], https://www.mygov.in/aarogya-Setu-app/.

[8] Online, [Available], https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200202 -sitrep-13-ncov-v3.pdf? sfvrsn=195f4010_6.

[9] M. Cardona, F. Cortez, A. Palacios, K. Cerros, Mobile Robots Application Against Covid-19 Pandemic, 2020 IEEE ANDESCON (2020) 1–5.

[10] T. Biswas, P. Kumar Maduri, R. Singh, R. Srivastava, K. Singh, Autonomous Robot to Perform Touch-less Assistance for Doctors, in: 2020 2nd International Conference on Advances in Computing, Communication Control and Networking (ICACCCN) (2020).

[11] T.M. Niamat Ullah Akhund, W.B. Jyoty, M.A.B. Siddik, N.T. Newaz, S.K.A. Al Wahid, M.M. Sarker, IoT Based Low-Cost Robotic Agent Design for Disabled and Covid-19 Virus Affected People, in: 2020 Fourth World Conference on Smart Trends in Systems, Security and Sustainability (WorldS4) (2020).

[12] M. Edelstein, L.M. Lee, A. Herten-Crabb, D.L. Heymann, D.R. Harper, strengthening global public health surveillance through data and beneft sharing, Emerg. Infect. Dis. 24 (2018) 1324–1330.

[13] C. Menni, A.M. Valdes, M.B. Freidin, et al., Real-time tracking of self-reported symptoms to predict potential COVID-19, Nat Med 26 (2020) 1037–1040.

[14] L. Qin, Q. Sun, Y. Wang, K.F. Wu, M. Chen, B.C. Shia, S.Y. Wu, Prediction of Number of Cases of 2019 Novel Coronavirus (COVID-19) Using Social Media Search Index, Int. J. Environ. Res. Publ. Health 17 (7) (2020) 1–14.

[15] X. Mei, H.C. Lee, K.y. Diao, et al., Artificial intelligence–enabled rapid diagnosis of patients with COVID-19, Nat. Med. 26 (2020) 1224–1228.

[16] S. Wang, B. Kang, J. Ma, X. Zeng, M. Xiao, J. Guo, M. Cai, J. Yang, Y. Li, X. Meng, Bo Xu, A deep learning algorithm using CT images to screen for coronavirus disease (COVID-19), Eur Radiol 31 (8) (2021) 6096–6104.

[17] X. Vincent Wang, L. Wang, A literature survey of the robotic technologies during the COVID-19 pandemic, J. Manuf. Syst. 60 (2021) 823–836.

[18] M.U.G. Kraemer, C.H. Yang, B. Gutierrez, C.H. Wu, B. Klein, D.M. Pigott, Open COVID-19 Data Working Group, L. du Plessis, N.R. Faria, R. Li, W.P. Hanage, J.S. Brownstein, M. Layan, A. Vespignani, H. Tian, C. Dye, O.G. Pybus, S.V. Scarpino, The effect of human mobility and control measures on the COVID-19 epidemic in China, Science, 368 (6490) (2020) 493-497.

[19] V. Lampos, M.S. Majumder, E. Yom-Tov, Tracking COVID-19 using online search, npj Digit. Med. 4 (17) (2021) 1–11.

[20] Online, [Available], https://www.moh.gov.sg/covid-19/.

[21] Online, [Available], https://med.stanford.edu/news/all-news/2020/04/wearable-devices-for-predicting-illness-.html.

[22] M. Nasajpour, S. Pouriyeh, R.M. Parizi, et al., Internet of Things for Current COVID-19 and Future Pandemics: an Exploratory Study, J. Healthc. Inform. Res. 4 (2020) 325–364.

[23] Online, [Available], https://support.google.com/sosalerts/?hl=en.

[24] Online, [Available], https://vigyanprasar.gov.in/isw/Self-check-kiosk-to-detect-prevent-Covid-19.html.

[25] Online, [Available], https://www.livemint.com/companies/start-ups/iit-bombay-passouts-develops-thermal-scanning-kiosks-with-facial-recognition-to-tackle-covid-19-11591812954291.html.