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Research Article

An Automated System to Limit the Spread of COVID-19 Using Screening BOT

Dhirendrakumar Rajak[1], Pratik Mevada[2], Yash Nandgaonkar[3], Aditya Chaughule[4], Priynka Sharma[5]

Abstract

The coronavirus has affected the whole world, which has increased the strain on the medical infrastructure of many countries and is the reason for some of the medical infrastructure to collapse. The robotic or automated system can greatly reduce the coronavirus transmission to healthcare workers, and common people by making it possible to screen, monitor, and treat people from a safer distance. The objective of this project is to develop a low-cost bot or automated system for screening individuals before entering into public space. The bot will check if the person has the symptoms of coronavirus before the entrance of the space and based on the result it will allow or disallow him/her from entering the public space. The screening service involves interactive questions that ask regarding common symptoms of coronavirus such as fever, cough, and cold, with the recording of body temperature, heart rate, and blood SPO2 level. It will also differentiate a person is wearing a mask or not wearing a mask. The bot will help the people to be less exposed to the suspected infected person in their spaces. Thus, this type of system process will reduce the chances of virus transmission through human contact.

Keywords: *coronavirus, screening, automated system, healthcare*

[1] Department of Electrical Engineering, Atharva College of Engineering, Mumbai, India, rajakdhirendra43@gmail.com
[2] Department of Electrical Engineering, Atharva College of Engineering, Mumbai, India, pvmevada014@gmail.com
[3] Department of Electrical Engineering, Atharva College of Engineering, Mumbai, India, yashsgn@gmail.com
[4] Department of Electrical Engineering, Atharva College of Engineering, Mumbai, India, adityachaughule1010@gmail.com
[5] Department of Electrical Engineering, Atharva College of Engineering, Mumbai, India, atharva.priyanka@gmail.com

Introduction

Coronavirus is a large family of viruses that can cause illness ranging from cold to more severe diseases like Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome Covid 19 or SARS-Cov-2 (Severe Acute Respiratory Syndrome coronavirus -2) comes under the family of coronaviruses. It was detected in humans for the first time in December 2019 and since then it has been pandemic all over the world[1]. At the time while writing this paper there are over 11.4 million confirmed cases and over 159,250 deaths in India[2]. The common symptoms of coronavirus which is declared by WHO are fever, dry cough, cold, tiredness, loss of taste and smell, etc. Precautionary measures such as cleaning hands, maintain social distancing, wearing a mask, avoid touching eyes, nose, and ears were recommended by WHO[3].

During the initial stage of the pandemic, the nationwide lockdown was imposed as a solution to fight against the pandemic. But it impacted badly on the economy of India and lockdown was not a permanent solution. Millions of people who were engaged in the unorganized sector had lost their source of income[4]. Finally, restrictions of lockdown were lifted, and slowly and steadily things started to take a pace. But as things started opening up there was a huge spike in Covid 19 patients and also few people were not taking precautionary measures. New strains of Covid 19 which were detected in the U.K., South Africa, Italy, India, and in many other countries make matter worse[5]. Some European nations are going through the second wave [6].

Hence, after lockdown screening has become an essential part of the public place as well as in workplaces. Screening has become important to control the spread of the virus and to avoid the entry of suspected patients of Covid 19. As fever is the most common symptom of Covid 19 conventional screening consist of thermal screening only which is inadequate, because nearly 40% of infected people don’t have symptoms of fever [7]. While other symptoms like heart rate, oxygen saturation are neglected. Also, there is some human intervention that makes the process vulnerable to the spread of the virus. With the help of robotics, we can overcome these loopholes.

The paper aims to design a bot that can help with the screening of a person for COVID-19. The paper also highlights the most recent works in the field of healthcare technologies in fighting covid-19. This bot will screen the person for symptoms and mask detection and based upon that it will draw a predictive statement whether the person should be allowed to enter the premises or not.

In healthcare, robotics is already being used, but it is not yet mainstream because of the high cost. This bot is using sensors that are readily available and open-source software which helps us to keep the cost low without compromising on the reliability. This makes it easier and less expensive for people to get access to high-quality care. The bot’s design is of lightweight and strong structure that also enables us to modernize our bot in the future.

The bot does not give 100% assurance that the person has Covid-19 or not and is only being used for screening purposes and to lower the chances of coming in contact with the person who shows early symptoms.

Related Works

In smart cities and other places has deployed system which can predict person who isn't wearing a mask or not. Mohammad Marufur Rahman [8] systems use an automated smart framework for screening people which detect through CCTV cameras and differentiate between who is wearing a mask or not wearing a mask and information is sent to the proper authority. These CCTV cameras are installed in public places such as Malls, Railway Station, Metro Station, Bus Stands, and in every part of smart cities where more than four to five people can gather and crowd the space. Urmil Bharti [9] proposed Chatbot also known as Medbot that uses Natural Language Processing to communicate with its users which includes Processing includes a Multilingual Voice Application to provide primary healthcare education and advice to chronic patients. It will also provide users healthcare consultation, counseling, and information with multi-lingual support to improve healthcare. To Predict the severity of the symptoms (respiratory rate, heart pulse rate, body temperature, and oxygen saturation level) of the COVID-19 virus in the people. Aman Dhadge [10] system uses ESP 32: Node MCU, MAX 30102, LM35, and a vibration sensor to monitor the patient's body condition . It classifies the patient symptoms into Severe, moderate, and normal depending on the measurements of the sensors. The device is useful to monitor the progress and continuous monitoring of the patient's by sending an alert as and when the patient's condition becomes severe. Autonomously controlled hand sanitizer dispenser robot which is designed to alleviate infections on human hands, nose, and face [11].

Mitra robot a humanoid robot by an Indian startup Invento Robotics, used by medical and non-medical is used for screening purposes in hospitals. It screens visitors for symptoms for COVID-19 such as fever, cough, and cold by using speech and facial recognition. It also has autonomous navigation and CRM applications and interacts with customers over voice [12]. To reduce the human interaction in contaminated places and to disinfect cleaning robots are used [13]. To avoid transmission of the virus during sanitization they play an important role, so there is no contact of humans to the infected areas and surfaces. The autonomous robot is used in fighting with COVID-19 in all the phases. In the first phase, the robot helps by collecting throat swabs samples from patients with the advantage of preventing medical staff at risk [14]. In the second phase, (quarantine time) they help in the diagnosis of the patient with COVID-19. IoT devices are used for real-time monitoring of patient health condition with the help of wearable which gives appropriate treatment remotely and by staying safe at home [15]. In the third phase (recovery phase), where there is a risk of reinfection, to avoid reinfection in patients and spread in their family social distancing and crowd monitoring devices are used which are based on IoT concept for better remote monitoring [16].

Vayyar Imaging [17] and Meditemi [18] are the devices that detect symptoms of COVID-19 in 10sec by using touchless scanning of a person within a distance of 1m to capture temperature and respiratory signs.

Methodology

We propose an automated low-cost system working on Raspberry pi4, which will screen every individual before entering into the public space or places which are densely crowded in this paper. This system will consist of sensors, camera, and other essential hardware which will measure important data of the individuals before entering into public space. Sensors will measure data on Body Temperature, Heart Rate, Blood SPO2 level of the person contactless manner and noninvasively who is taking the screening test. The camera is used for real-time detection of whether that person is wearing a mask or not wearing a mask. This system will have an interactive questionnaire that will be related to the medical state of the person, mostly this questionnaire will contain common symptoms of COVID-19 disease. Based on the measured sensor data, mask detection, and interactive questionnaire, the system may allow or disallow him/her entering into the public space. The flowchart of the developed system is shown in Fig. 1 represents the workflow of the developed system. Fig. 2 represents the circuit diagram of the system.

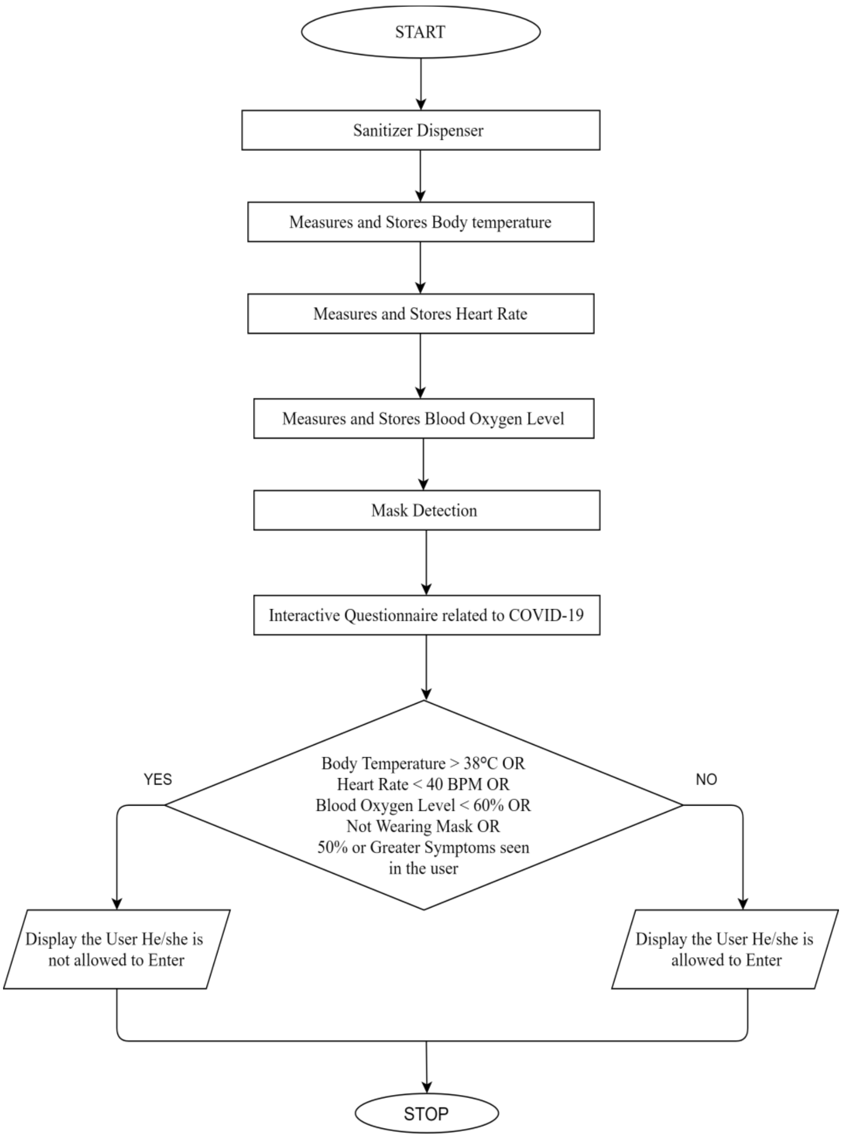

Fig. 1 Flowchart of the developed system

This system consists of the following essential components:

1. Raspberry Pi 4 2GB
2. Max30102 (pulse oximetry and heart-rate module)
3. Mlx90614 (infrared thermometer)
4. Hc-sr04 (Ultrasonic)
5. Diaphragm pump
6. WebCam (Zebronics Zeb-Crisp Pro)
7. 7″ touchscreen monitor for Raspberry Pi

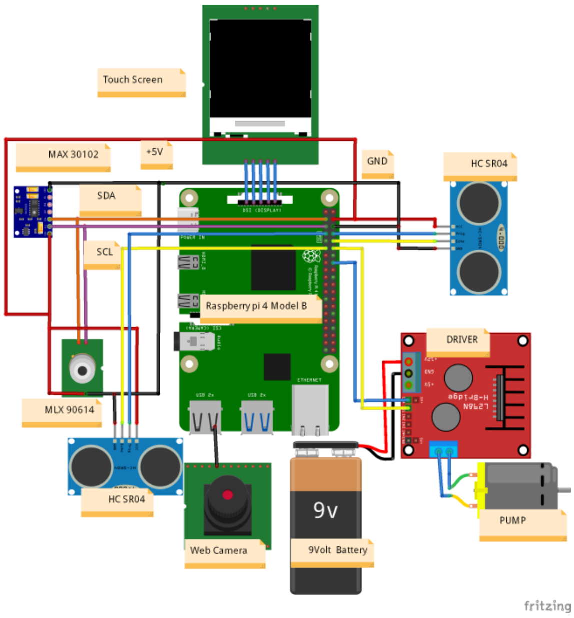

Fig. 2 Circuit diagram of the system.

Measuring Vital Data by Sensors

1. SANITISER DISPENSER: We are using a non-contact sanitizer dispenser setup which is using two essential components an ultrasonic (Hc-sr04) module and a Diaphragm pump. Diaphragm pump is a positive displacement pump that uses two flexible diaphragms made of rubber, thermoplastic or Teflon, that reciprocates which creates a temporary chamber, which results in drawing in and expelling out fluid through the pump. In this sanitizer dispenser, an ultrasonic sensor is used to detect the presence of hand below the outlet of the pump. The pump is driven by an L293d motor driver, which is connected to the GPIO of Raspberry pi. The echo (receiver) and trigger pin of the ultrasonic sensor is connected to the GPIO of Raspberry pi, which triggers the sound wave and is collected by the ultrasonic sensor. The ultrasonic sensor continuously calculates the time delay between the transmission of a sound wave and receiving of a sound wave and depending on the delay it calculates the distance between the hand and the outlet of the pump [19]. When the distance between the hand and pump outlet is less than 5 cm Raspberry pi will give the driving signal to the motor driver to switch ON the pump for 3 seconds and it will switch it OFF the pump, so the wastage of the sanitizer is avoided.

2. BODY TEMPERATURE: For measuring user body temperature, contactless MLX90614 ESF Infrared Temperature Measurement Module is used with an ultrasonic (Hc-SR04) module. MLX90614 is a contactless Infrared Temperature Measurement Module, it consists of two pairings of two devices i.e. an IR thermopile detector (MLX81101) and a signal-conditioning application processor (MLX90302). IR thermopile detector is a thermocouple that converts heat energy applied to the device into electrical energy (potential difference). Signal conditioning ASSP MLX90302 manipulates the analog signal such that data is available for the next stage for processing. MLX90614 module based on Stefan-Boltzmann law, that states that any object above absolute zero (-273°C or 0°K) will emit light which is in the infrared spectrum and which will depend on the wavelength of infrared light. Thermophile will produce a voltage which is passed to the application processor's 17-bit ADC then it is passed to Raspberry Pi 4. The sensor is connected to Raspberry Pi 4 by I^2C bus where SDA and SCL of the sensor are connected to SDA and SCL of Raspberry Pi 4. The data signal is controlled bidirectionally. The I^2C address of MLX90614 is 0x5A which is the default address of the sensor which can be changed [20]. The reading of the MLX90614 module is affected by the distance between them, if the distance between object and sensor is large the error in the measurement increases, so for higher accuracy in temperature measurement, the distance between object and sensor should be less. The ultrasonic sensor is used to detect the presence of the user's hand from the sensor. The ultrasonic sensor continuously calculates the distance between the user and the MLX90614 sensor. When the distance between the user and the sensor becomes less than 3cm Raspberry pi will measure the temperature of the user.

3. SPO2 AND HEART RATE: SpO2 and Heart Rate of the user is measured by MAX30102 integrated pulse oximetry and heart-rate monitor biosensor module. MAX30102 module comprises internal LEDs (IR LED and Red LED), photodetectors, optical elements, and low-noise electronics which can reject ambient light. MAX30102 measures Blood oxygen level and Heart rate noninvasively by transmitting light-absorbing the reflected light by human tissues Transmitting light pulse of oximeter is generated by LED (red-colored) which is placed on the opposite side of the finger (or user body). An Integrated LED driver in the sensor modulates the red and infrared LEDs and a photodetector is used to collect the reflected light. Some of the transmitted light gets absorbed by body tissue and reflected light that passes through various depths underneath the skin is collected by the integrated photodiode. Light gets absorbed by the pulsatile arterial blood and incident lights get modulated passing through the skin and tissues and it forms PPG (Photoplethysmographic) signal. AC components generated by pulsatile arterial blood are superimposed with DC signal which will collect effects of absorbed light by blood and tissue. MAX30102 has an internal ADC that has 18-bit resolution and continuous-time oversampling sigma-delta converter and has a sampling rate of 10.24MHz [21]. The sensor module is connected to Raspberry pi 4 through an I^2C 2-wire serial interface, SCL and SDA are connected to SCL and SDA of RPI. Data can be controlled in both directions as SDA is bidirectional. By I^2C bus the Heart Rate and SpO2 is measured and calculated using the MAX30102 biosensor module

Mask Detection

We are currently using a model that is already trained with 1000 images. However, the size of the dataset can be increased and the model can be trained for improving accuracy. This dataset is provided by Caroline Dunn on GitHub [22] and from Kaggle. In the mask detection operation, we are using a webcam to detect whether the user is wearing a mask or not. The Phyton code uses TensorFlow and OpenCV packages. A red square will be displayed the user who is not wearing a mask and a green square for the user wearing a mask. The dataset consists of two folders, with_mask, and without_mask which contains the respective category of images. The training algorithm is used to create a model to differentiate between the mask and no mask based on these images.

1.Incorporated Packages: Open CV (Open-Source Computer Vision) library is used for machine learning and computer vision. TensorFlow is an open-source numerical computing library for Python that makes machine learning faster and easier. KNN K-Nearest Neighbour is a Supervised Learning algorithm that is one of the simplest Machine Learning algorithms.

Fig. 3 Dataset images (Wearing a mask and not wearing mask respectively)

2.Training: For training of model 2 python codes are provided which will be used to take photos with a webcam for a user with a mask or user without a mask and will be added to their respective folders. Fig. 3 shows some of the example images in the dataset. Then based upon the newly updated dataset the model is trained. In this step sklearn and matplotlib packages are also installed. Machine learning and statistical modeling methods, such as regression, clustering, classification, and dimensionality reduction, are available in the sklearn library. Matplotlib which is a numerical extension of NumPy is a cross-platform data visualization and graphical plotting library for Python. In the end, the model is updated with the new dataset. Fig. 4 shows the flowchart for training and detection phase. The trained model is then loaded for the detection phase.

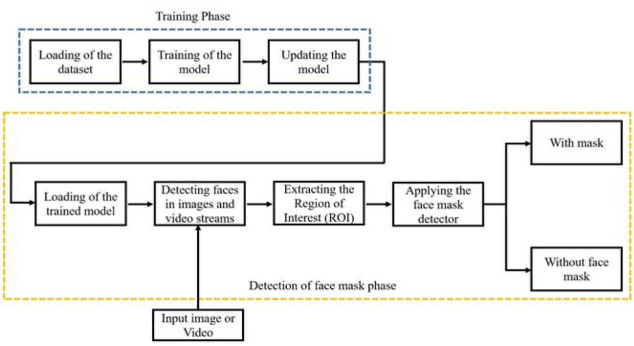

Fig. 4 Flowchart for training and detection phase [12].

3. Detection/application phase: For the detection phase the webcam is used for giving the input images or video to the model. The model will then detect the faces from the images or video stream and based upon the region of interest the face and will detect whether a face mask exists or not in the current input images or video stream. In the end, the model will classify the face as with mask or without mask [23].

Interative Questionnaire

Once a person has contracted coronavirus it can take 2-14 days for symptoms to appear. The average incubation time is ranging from 5-14 days. Symptoms of coronavirus can be mild and gradually can show serious symptoms. One who is suffering from corona may also have a combination of two or more than two of the following symptoms. Hence it becomes necessary to take other symptoms into account like:

- fever,
- dry cough,
- shortness of breath,
- headache,
- muscle pain,
- sore throat,
- smell and taste disturbance,
- fatigue [24].

We cannot judge a person only based on high body temperature, we need to know whether a person is having other symptoms or not. Some symptoms like nausea, sore throat, muscle pain, or smell and taste disturbance are based on their personal experiences. Hence to get those symptoms bot will ask few questions through a digital screen. For a more user-friendly experience, we have used a Graphical User Interface (GUI). Python module called Tkinter has been used for creating GUI.

The questions based on common symptoms will be in ‘yes’ or ‘no’ format, whether that person has that symptom or not. The user has to pick one option after selecting the option the next question will come up. By this questionnaire, we will take those necessary inputs from the user and at the end, it will display the result of the entire screening process that will consist of body temperature, oxygen saturation level, mask detection, and heart rate will be displayed on the screen. Based on the questionnaire if a person has chosen ‘yes’ to 50% or more of the symptoms, the bot will instruct the user that he/she has been disallowed to enter the public space. And the one who has less than 50% of the symptoms he/she will be allowed to enter the public space.

Results

A. Measurement by sensors

In this section, we will test the accuracy of data measured by the sensors in the project with the medical standards measuring instruments. The Bot sensors reading (B.R.) (Heart Rate, Blood Oxygen level, and Body Temperature) used in the project is compared with the standards medical (S.R.) measuring instruments (Body temperature is measured by clinical digital thermometer and Heart Rate and Blood oxygen level is measured by Generic Oximeter). From the Table 1 it is found that the error between the B.R. of Body temperature is very less in the range between 2.5% to 6.4%, the error of the heart rate B.R. ranges from 0.93% to 6.3%, and the error between blood oxygen level B.R ranges between 1.04% to 3.2%. Table 2 shows the average accuracy of the sensors where the SpO2 sensor is most accurate with an average accuracy of 97.8%, Temperature sensor has an average accuracy of 95.8%, and Heart Rate sensor has an average accuracy of 96.5%.

B.R.- Bot sensors reading used in the project

S.R.- Standard medical instruments

Age	Heart rate BPM		SpO2 Level %		Body Temperature °C	
	S.R.	B.R.	S.R.	B.R.	S.R.	B.R.
21	80	83	95	92	36	33.71
23	108	107	96	97	36.3	35.15
45	48	51	72	70	32.63	33.45
21	93	97	98	100	36.5	35.45
22	91	93	97	99	36.4	34.21

Table 1 Test results (S.R vs B.R.)

Vital measurements	Average Accuracy %
Heart Rate	96.5
Body Temperature	95.8
Oxygen Saturation	97.8

Table 2 Sensors Accuracy (based on the test readings)

B. Mask Detection

The average accuracy of the model trained with 1000+ images after 15 epochs is almost 98%. The val_loss after 15 epochs is less than 0.1. The accuracy of the model with 113 images (56 with mask and 57 without mask) is 100 %. Fig. 6 shows images with the highlighted red and green square for the user without the mask and with mask respectively. Fig. 5 shows that the difference between the train and test accuracy is very minimum. The average accuracy of the model trained with 1000+ images after 20 epochs is 98%. The training also reduces with an increase in the number of epochs.

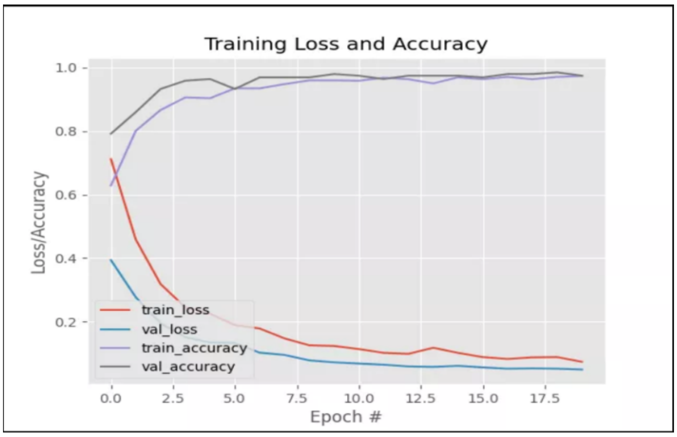

Fig. 5 Training loss and accuracy

The val_loss after 20 epochs is less than 0.1. Thus the model has sufficient generalization capability for the test dataset. The accuracy of the model with 113 images (56 with mask and 57 without mask) is 100 %.

Fig. 6 The output of Not wearing Mask, improperly wearing Mask and wearing Mask respectively

	precision	recall	f1-score	support
with_mask	1.00	1.00	1.00	12
without_mask	1.00	1.00	1.00	12
accuracy			1.00	24
macro avg	1.00	1.00	1.00	24
weighted avg	1.00	1.00	1.00	24

Fig. 7 Accuracy of the model with 113 images

Conclusıon

As the covid19 spreads, complemental technologies such as robotics will be playing an increasingly critical role in public health management. By properly implementing IoT technology in healthcare, more medical staff can conduct checkups from a distance and tackle a surge in duties and missions.

This paper presents a bot that is designed to achieve the objective - to help the medical staff and reduce the spread of coronavirus while being of low cost. The bot will measure parameters such as heart rate, SpO2 level, and body temperature and feed this data to an algorithm and it will draw a predictive statement whether the person should be allowed to enter the premises or not. Mask detection is added since the mask is a basic precautionary measure against COVID-19. As COVID- 19 is a global pandemic, the bot is designed to be straightforward and inexpensive without compromising its efficiency.

The bot can be used post-pandemic by medical staff for collecting vital data of the patients via remote monitoring.

It is to be kept in mind that the bot does not give 100% assurance that person has covid19 or not and is merely used as an automated screening device to help reduce the spread of the coronavirus.

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