Smart Door Bio Sentry

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Abstract. With the history of various virus-based contaminations and present-day tragedy of Covid-19 this fully featured virus spread control work provides a decentralized way to control and prevent such infections. The team did a deep dive into existing models which offer the desired functionality. It was noticed that most of the functions were available only in separate packages. Our work will be a fully featured virus spread control system ensuring safety and security of affected and vulnerable citizens during covid-19.

INTRODUCTION

COVID-19 is a contagious disease that acutely affects the respiratory system and, in most instances, transmitted through respiratory droplets. It has made the practice of social-distancing and implementation of strict guidelines like wearing a mask, proper sanitation, and temperature checks very essential [1]. To be able to implement both aspects, least human intervention and monitoring the adherence to the guideline, we have proposed a fully featured virus spread control system ensuring safety and security of affected and vulnerable citizens. We aim to develop a hardware prototype which will consist of Face Mask Detection, Temperature Sensing and Sanitizer Dispenser in order to avoid COVID-19 breach. With the history of various virus-based contaminations and present-day tragedy of COVID-19 this fully virus spread control work provides a decentralized way to control and prevent such infections [2-3]. The paper discusses a novel approach to monitor and minimize the spread of infectious diseases like corona from carriers who may be customers to business establishments or visitors at the household level. The proposed system ensures security in the form of facial authentication while providing assurance through other physical parameters. A temperature sensor with a minor degree of error is chosen. Different parameters like accuracy, feasibility and applicability of various existing machine learning models are analyzed along with their performance in various contexts and the best performing model is chosen to be deployed in our product. The architecture developed for mask detection ensures precision while maintaining feasibility. The system enables the owner to receive remote alerts over the air [4].

The designed product of this work aims to satisfy these functions:

- The system will detect whether the customer/visitor is wearing a mask or not. If not, the system would prompt them to do so.
- Then, it checks if the body temperature of the visitor is between the range of 36.5°C (97.7°F) to 37.5°C (99.5°F). And lastly, the system automatically dispenses sanitizer. After this, the door opens, allowing them access.
- As a backup, the system also sends a notification to the owner via air.

PRIOR WORK

P. Singhal et al. in their work discuss various databases and methods for resolving the face identification and recognition problem which provides an overview of the numerous researchers' contributions to the study of identification and face recognition [5]. They focus on the process of facial identification and authentication using minimally processed, uncontrolled faces for individual images and videos. They discuss complex methods for their facial identification and recognition applications by describing a number of facial files, real-time images, and videos. To anticipate content related to face detection and recognition, a machine learning strategy using numerous image datasets enhances the effectiveness of the classifier [7]. P. N. Achyutha et al. in their paper investigate and evaluate Machine Learning (ML) technologies for identifying and recognizing people wearing face masks in any previously shot footage, still images, or in real-time (real-time) situations [8]. This is intended to assist in developing a real-time Automated Facial Recognition and Mask Detection System based on Graphics User Interface. The HAAR Cascade Algorithm and Principal Component Analysis (PCA) are the algorithms employed in the suggested methodology. A red coloured box would be displayed around the area of the face in the image, if the respective person on the camera is not wearing a mask, while a green-coloured box would be displayed around the section of the face, if that person is wearing a mask. This model has a 99% accuracy rate [9].

The research done based on a novel approach for accurate health monitoring utilizing Artificial Intelligence based models. To ensure the members' health, proper monitoring and symptom identification are crucial. To achieve comparative increased results, a variety of ML (Machine Learning) techniques have been applied to this model, which was developed employing many IoT components [10]. The main piece of hardware, a Raspberry Pi 4 model B, is connected to several sensors, including the MLX906014 non-contact thermal sensor, the MAX30100 pulse oximeter, and the heart rate sensor, to measure pulse rate and calculate blood oxygen levels without making direct contact with the subject. A camera module has also been employed to enable face recognition capabilities for gadgets. If an abnormal temperature and/or oxygen level is detected, an Alert will be sent to the admin. Information is kept in the Firebase database, which is updated in real-time. The administrator can monitor and further analyze a person's health history using graphs for visualization. From the work in [4] done by Z. Wang et al. discuss various types of datasets for masked faces: the Masked Face Detection Dataset (MFDD), the Real-world Masked Face Recognition Dataset (RMFRD), and the Synthetic Masked Face Recognition Dataset. (SMFRD). Additionally, benchmark tests are run on the three datasets as a guide [11-12].

The work on a real-time mask detection system using YOLOv3 (You Only Look Once version 3) for preventing the spread of COVID-19. The system consists of two stages: mask detection and face recognition. In the mask detection stage, YOLOv3 is used to detect whether a person is wearing a mask or not, while in the face recognition stage, OpenCV is used to recognize the person's identity. The researchers collected a dataset of 10,000 images of people wearing and not wearing masks in different environments, including indoor and outdoor settings, and various lighting conditions [13]. They used this dataset to train the YOLOv3 model for mask detection. The model achieved an accuracy of 98.4% on the test dataset. To evaluate the system, the researchers conducted experiments on a live video stream of people entering a building. The system was able to detect whether people were wearing masks or not in real-time, and the face recognition module successfully recognized individuals. Studies done in by M. Farooq et al. propose a real-time mask detection system using Convolutional Neural Networks (CNN) and YOLOv3. The system consists of three stages: face detection, mask detection, and face recognition. In the face detection stage, a pre-trained CNN model is used to detect faces in the input image. Then, YOLOv3 is used to detect whether a person is wearing a mask or not. Finally, the face recognition module is used to recognize the person's identity. The authors collected a dataset of 2,000 images of people wearing and not wearing masks in different environments and lighting conditions. They used this dataset to train the YOLOv3 model for mask detection. The model achieved an accuracy of 96.5% on the test dataset. To evaluate the system, the authors conducted experiments on a live video stream of people entering a building. The system was able to detect whether people were wearing masks or not in real-time, and the face recognition module successfully recognized individuals [14].

The work proposes a real-time mask detection and recognition system based on YOLOv3 and deep face recognition. The system consists of three stages: face detection, mask detection, and face recognition. In the face detection stage, YOLOv3 is used to detect faces in the input image [15-16]. Then, a mask detection model is used to detect whether a person is wearing a mask or not. Finally, the face recognition module is used to recognize the person's identity. The authors collected a dataset of 5,000 images of people wearing and not wearing masks in different environments and lighting conditions. They used this dataset to train the mask detection model and the face recognition module. The mask detection model achieved an accuracy of 97.5% on the test dataset, while the face recognition module achieved an accuracy of 98.7%.

The work on integrated face detection followed by face recognition procedures. They used python along with OpenCV to implement an efficient face recognition system using deep learning techniques. OpenCV provides computational usefulness with focus on continuous applications. Therefore, it is preferred for face recognition using a camera. Most deep learning methods struggle with accuracy as face masks are small objects. Akhil Kumar et al. in their paper discussed the use of ETL-YOLO v4 with improved feature extraction and prediction networks. To create ETL-YOLO v4, the architecture of tiny YOLO v4 was improved. The proposed ETL-YOLO v4 was able to achieve 9.93% higher map, 5.75% higher average precision (AP) for masks, and 16.6% higher average precision (AP) for the face mask region as compared to its original base-line variant [16].

Studies done in by S. Alomar et al. present a temperature sensing system using the MLX sensor and Raspberry Pi. The MLX sensor is used to measure the temperature, while the Raspberry Pi is used as a microcontroller to read the temperature data and display it on a monitor. The authors designed and implemented the system and conducted experiments to evaluate its performance. They found that the system was able to accurately measure temperature with a mean error of 0.2 degrees Celsius. They also found that the system was able to detect changes in temperature quickly and efficiently. The authors concluded that their temperature sensing system using MLX sensor and Raspberry Pi could be used in various applications, such as home automation, weather monitoring, and industrial control systems. S. D. Adams et al. in their work described how screening for disease was performed earlier. Four different characteristics of measurement were proposed, to achieve an ideal screening solution: non-contact, effective, rapid, and low-cost measurements. They also looked into the existing literature regarding fever-screening using non-contact infrared thermometer (NCIT) devices and infrared thermography (IRT) devices, as these are two technologies which have experienced increasing use.

Giselle Ann Alcoran Alvarez1 et al. in their paper proposed a cost-effective, social distancing and human body temperature monitoring module using Arduino as the base. They used an ultrasonic, an IR thermometer, to control the spread of COVID19 in public places. The fully automated features of both social distancing and body temperature sensing minimizes the contact from person to person and thus preventing the spread of the virus.

SYSTEM ARCHITECTURE

Raspberry Pi (Fig.1[a]) is a series of small, single-board computers that are cheap and versatile. It is widely accessible for a lot of users, including hobbyists, students, and professionals. The Raspberry Pi board contains a microprocessor, memory, input and output interfaces, and various connectors, all integrated into a credit card-sized form factor. It usually runs a Linux-based operating system and can be connected to a monitor, keyboard, mouse, and other peripherals. MLX90614 IR Temperature Sensor (Fig.[b]) is a temperature sensor that measures the temperature of objects without making physical contact. It is based on the principle of infrared radiation emitted by objects, which correlates with their temperature.

An ultrasonic sensor (Fig.1[c]) is a device that uses ultrasonic waves to detect the distance to an object or the presence of an object within its range. It consists of a transmitter that emits high-frequency, ultrasound waves and a receiver. The receiver detects the echoes of the transmitted waves after they bounce off the object. By measuring the time taken for the waves to travel and return, the sensor can calculate the distance to the object. Raspberry Pi Camera Module - The Raspberry Pi camera module board (Fig.1[d]) is a 5MP camera that can capture good quality photos as well as take videos. It is a good fit to be used with drones and other raspberry pi works. Servo Motor (Fig.1[e]) allows for precise control of angular or linear position, acceleration, and velocity. In order to get feedback on the position, the motor is coupled to a sensor. The order of working of these components are shown in Fig.2.A sophisticated controller is also required for use with servomotors. The low level architecture of work is shown via Fig.3.

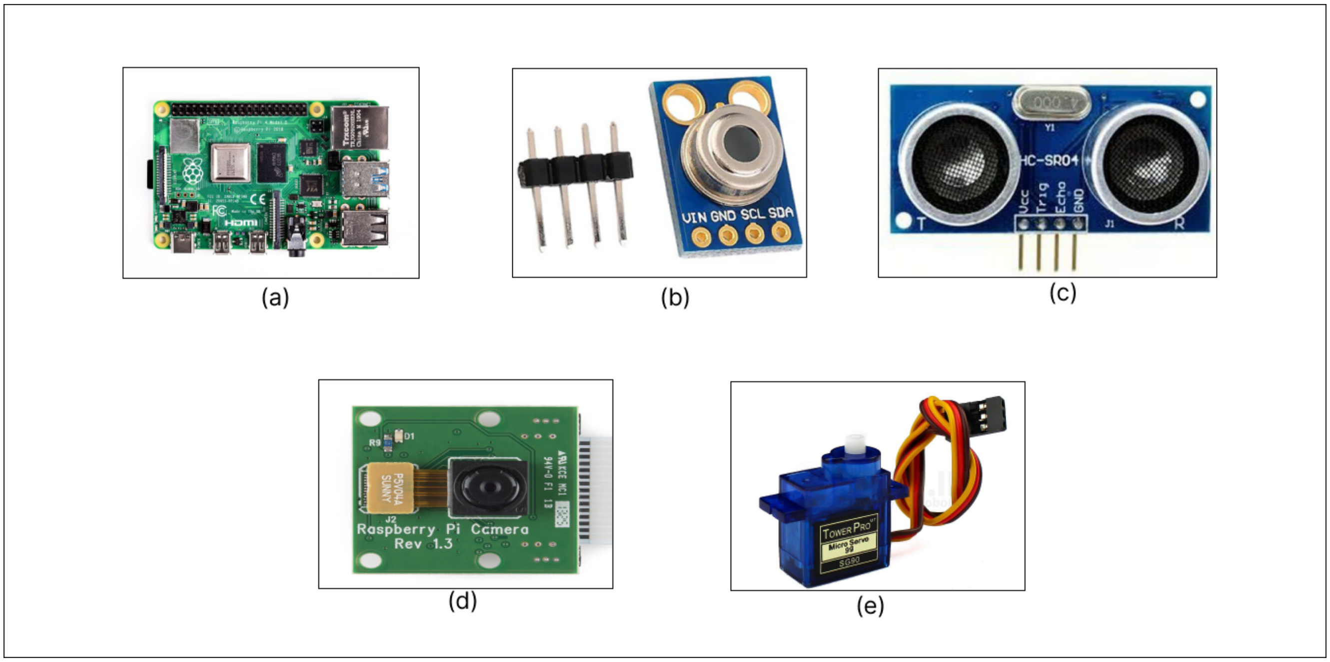

FIGURE 1. Represents hardware components used, (a) denotes a Raspberri Pi module, (b) represents the MLX90614 Temperature Sensor, (c) shows an ultrasonic sensor, (d) represents a Raspberry Pi camera module and (e) denotes a servo motor

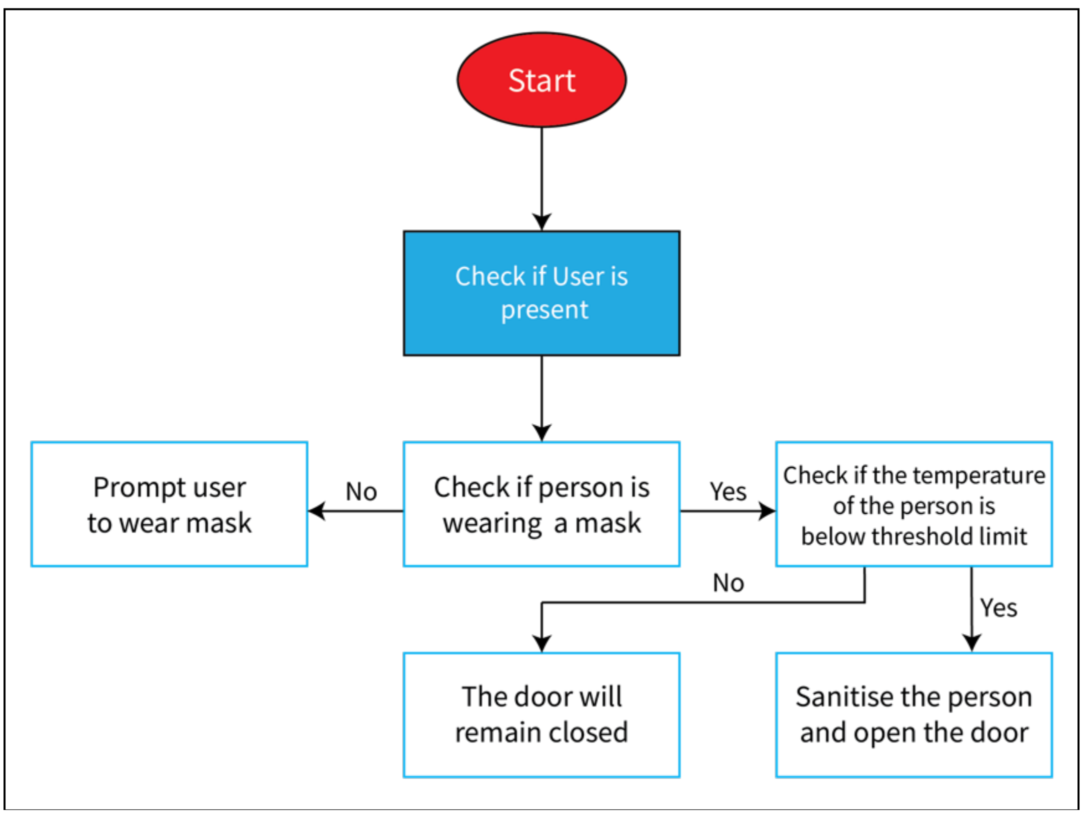

FIGURE 2. Flowchart of the working of the system

The software and libraries required in the making of this work are Raspberry Pi OS, Yolo v3, Open CV and Fritzing.

WORKING

The entire design approach can be visualised through Fig.4. The RPi camera detects the human face and checks whether the person is present or not. This is achieved through the haar cascade classifier. Yolov3 mask detection consists of three components: Training, Testing, and Data Preparation, as described below:

- Data Preparation: We web scrape thousands of photographs of people wearing masks and people who are not wearing masks for this module and store them in two distinct folders. Then, by drawing a bounding box across the face and assigning a label to it, we use the ImgLabel tool to label the photos, creating an array of 9 components (x1, y1, x2, y2, x3, y3, x4, y4, label)
- Training: In this stage, we give the photos and the associated image processing arrays to the YoloV3 model. This model accepts the input images as a 3d array and simultaneously passes them to the ReLu and MaxPool layers, taking a 9-element array with each image. The sliding window approach settles down to the perfect coefficient values after several iterations, providing us with the optimum outcome for future prediction.
- Testing: Following the temperature check, the ultrasonic sensor will determine whether the hand is within proximity, and if it is, the servo motor will revolve in clockwise direction to start the sanitizer dispenser and then counter clockwise to open the door. This combined task has been carried out with a single servo motor.

The MLX temperature sensor is connected through the breadboard pins to the Raspberry Pi module which is then configured using Python program to fetch the values of the body temperature and the surrounding temperature. In Python program, we can set the limits of flags to allow the user to access if temperature is in permissible range or not. After checking the temperature, the ultrasonic sensor will sense if the hand is in a close range and if it is then the servo motor will rotate in clockwise direction first to trigger the dispensing of the sanitizer followed by anticlockwise rotation to open the door. The synchronization between the hardware components and backend can be observed via the system analysis graph in Fig.5.

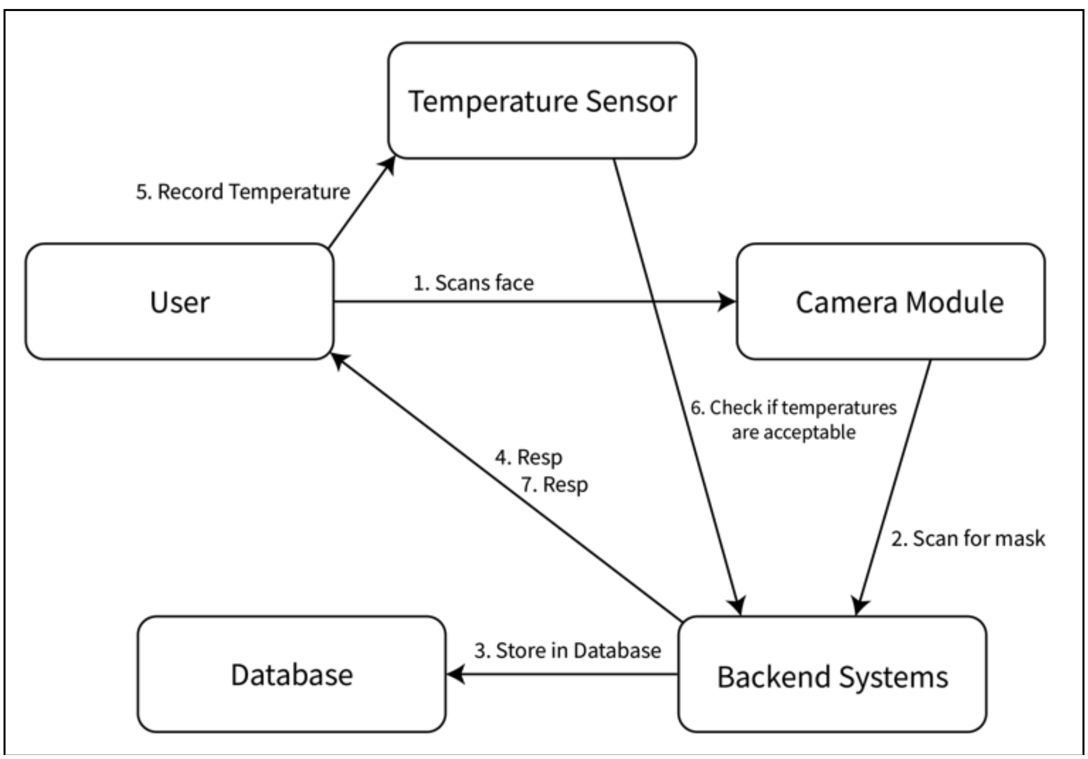

FIGURE 3. Shows a datagram of the low-level architecture. It is an overview of the functioning of the prototype.

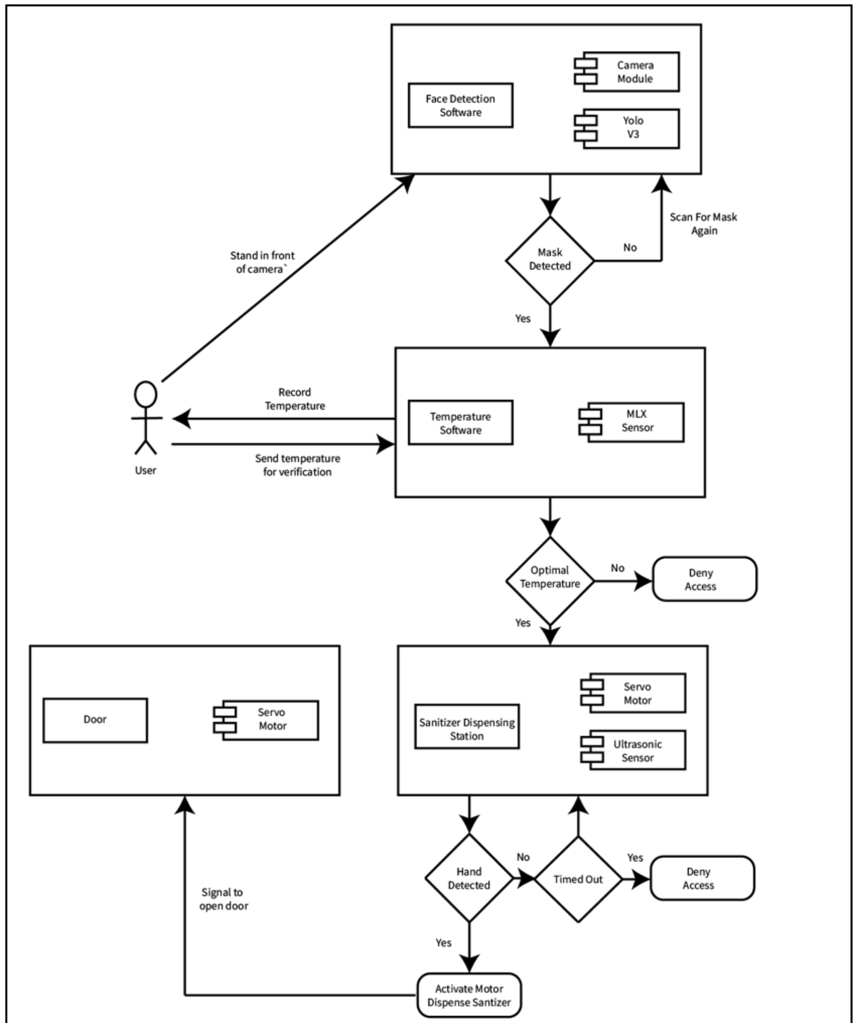

FIGURE 4. Design approach

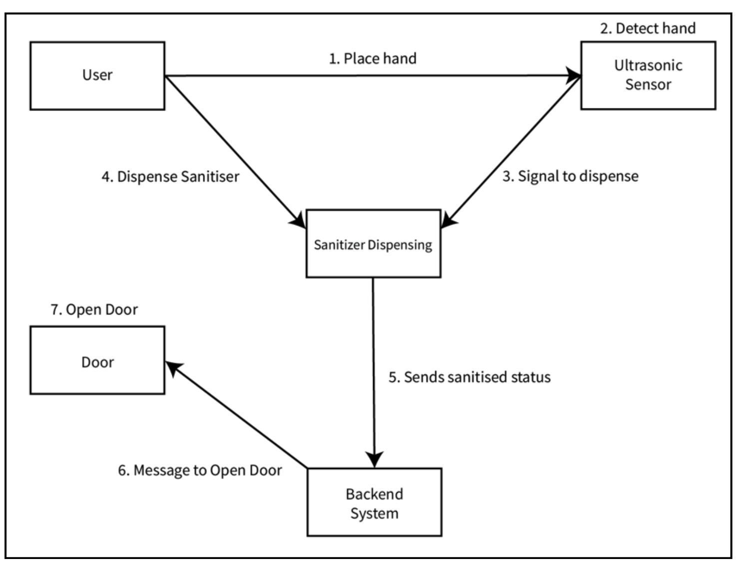

FIGURE 5. Shows the flow of detection and analysis systems incorporated in this work

CONCLUSION

In this paper, complete design and implementation of a Smart Door Bio Sentry system has been proposed. The task of merging the three elements in a hardware prototype—Face detection, Mask detection, and Sanitizer dispensing in addition to Door opening has been successfully completed. A small prototype that can subsequently be applied on a large scale and at the industry level has been developed. Soon, we can integrate this into a huge organization level and install it practically everywhere. As a result, it will be possible to properly deploy this approach of creating a device which can protect people from the virus. In the present world economy, total lockdown is not a viable option for countering the virus, and thus a way to actively minimise further spread is essential. The developed product is viable in various scenarios preventing future outbreaks.

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