Entracer - Contact Tracing and Sanitization Device

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ABSTRACT — OBJECTIVE: *In this time of great distress brought about by the COVID-19 pandemic, hand sanitization is of utmost priority to prevent the transmission of germs. We have developed an automated hand sanitization and contact tracing device which will be immensely beneficial in flattening the curve of COVID-19 cases.*

MATERIALS AND METHODS: *The device described in this paper automates the preliminary testing of COVID-19 symptoms which are high temperature and low blood oxygen level. This paper addresses the methodological details of the proposed device while also focusing on its UI and the ecosystem of App and the device.*

RESULTS: *The device integrates all the important features for preliminary COVID-19-*

19 screening and makes the process of sanitization rapid and easier.

CONCLUSIONS: *This idea is anticipated to be adopted at closed places at first like college campuses, offices, malls, and other buildings, then slowly it can be expanded to cover entire states and track potential patients so they can be advised to maintain quarantine and reduce the risk of spreading the virus*

KEYWORDS
Internet of Things, Raspberry Pi, Coronavirus, Hand hygiene, Sanitization, Temperature Screening, Contact-less technology, Contact Tracing.

INTRODUCTION

Coronavirus has affected the entire world. Due to its constantly changing property and high r0 value, it is a highly dangerous virus that has affected millions of people and has taken millions of lives (1.6 mil at the time of writing this paper). Then it has become imperative that we maintain social distancing with anyone who is at risk of having COVID-19 and also that we maintain proper hand hygiene. Hand hygiene norms obedience is boosted when convenient and readily accessible dispensers are installed[1]. At many places like college campuses, malls, offices, etc. guards are appointed to measure everyone's temperature, blood oxygen level, and disperse sanitizer to them. But this process is highly inefficient due to several factors, for example, if the guard has asymptomatic coronavirus then the health of everyone will be at risk. Also, the measurement is manual, and no track is maintained. According to previous research[2], hand hygiene compliance increased from 36.3% to 70.1% by the use of electronic devices. Using contact-based devices pose a wide risk of cross-contamination, hence devices with touch-less features need to be developed and implemented to contain the spread of the virus. In this paper, a device and app ecosystem which is capable of electronically dispersing sanitizer and also measure a person's Blood Oxygen level and body temperature and also notify to people on their mobile device if ever they come in contact with any high-risk COVID-19 person is proposed and all of this is done by contact-less technology. The proposed IoT enabled device has

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a web-based database which facilitates the transfer of details of people with high temperatures to Health Department authorities.

MATERIALS AND METHODS

Some COVID-19 patients suddenly develop the condition called "silent hypoxia," during which they still look and feel comfortable, but their SpO2 is dangerously low. This can happen at home or in hospital. COVID-19 related pneumonia can be predicted by low Blood SpO2 level and it requires the patient to be kept on ventilator[3]. COVID-19 can be tracked at home to some extent. If a person's blood oxygen level drops below a threshold value, the patient needs to see a medical practitioner for guidance. The easy use and availability of pulse oximeters make it an attractive option for people to identify the problems at an early stage[4]. Blood oxygen level is an important factor for the early detection of COVID-19 in patients, even some of the asymptomatic patients can be detected by this method. According to WHO SpO2 level of 95 and above is good for a healthy person and indicates a low risk of COVID-19, while lower than 95 gives us high risk, and if a person's oxygen level is less than 90 he/she needs immediate medical attention.

Fever is a common symptom of COVID-19 and is observed in most COVID-19 patients. The degree of temperature elevation sometimes reflects the severity of the condition[5]. Another important factor that helps in identifying potential COVID-19 cases is elevated body temperature[6]. The first reaction of the human body to most of the viruses is fever. Therefore, this can be used to predict COVID-19 cases. For our project, we have set the threshold at 99.5°F or 37.5°C.

PROCESS TO BE FOLLOWED

When a person reaches a machine the procedure, he/she needs to make the following procedures (Figure 1):

- Put his finger in the compartment made for oximeter to measure his temperature.
- A red LED will notify if the oxygen is being measured, and when the LED turns green the person can remove his finger.
- Then the person will take 5 seconds to stand in front of the temperature sensor to measure his body temperature. A red LED will let the person know when the temperature is being measured and when it turns green the person can step away.
- Next, Oxygen and Body temperature will be shown on the LCD Display on the device.
- If the person's vital signs (Temperature and Blood Oxygen) are below the prescribed level, a green light at the center of the device is displayed or else an alarm beeps notifying the person that his/her vital levels are not okay, and they should practice self-isolation.
- These readings are also sent to the authorities of the institution, where the device is installed, and are also visible to the person on their phone App.
- Now once a person enters an institution, he/she will get a notification when anyone with a high risk of coronavirus comes near them.
- They will get an instant alert on their phone with the person's name, photo, and readings.

COMPONENT LIST

The components required for the device are:

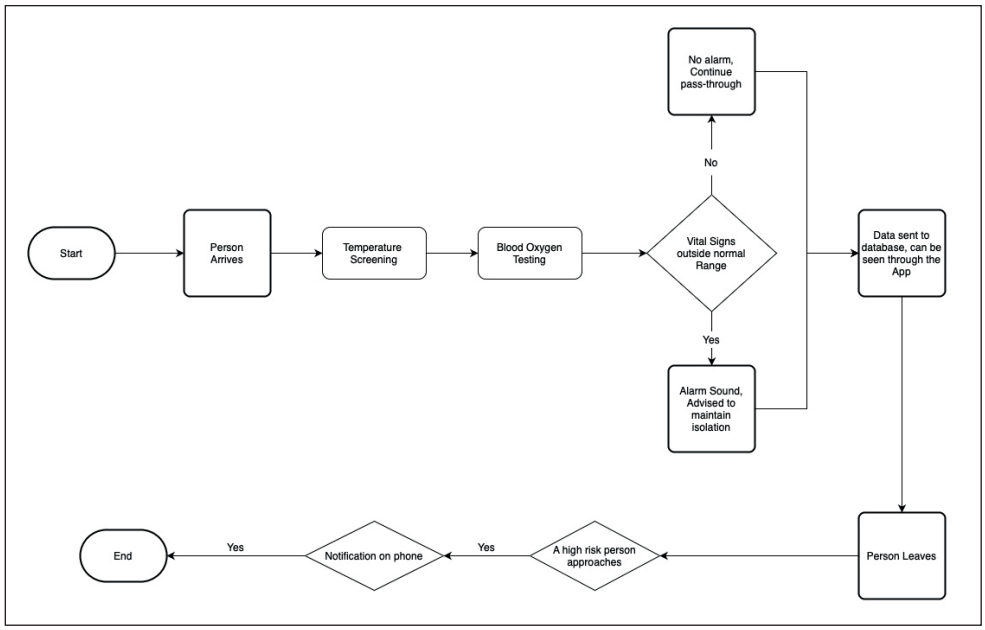

Figure 1. Algorithm.

Raspberry Pi

Raspberry Pi is the name of a series of single-board computers made by the Raspberry Pi Foundation, a UK charity that aims to educate people in computing and create easier access to computing education. The Raspberry Pi is a very cheap computer that runs Linux, but it also provides a set of GPIO (general purpose input/output) pins that allow you to control electronic components for physical computing and explore the Internet of Things (IoT). Any version of raspberry Pi would suffice as long as it has wireless connectivity; otherwise, a WiFi module must be used.

Chassis

A 3D printed self-designed chassis for fitting all the components and sensors (Figure 2). The chassis is designed in Solid-works. A 3D model image is shown in the image below.

Camera

The Pi camera module is a portable lightweight camera that supports Raspberry Pi. It communicates with Pi using the MIPI camera serial interface protocol. It is normally used in image processing, machine learning, or surveillance projects. This will be used for person detection and obstacle avoidance. In this project, we use a 5 MP Pi-Cam.

Power Supply Unit

This would be an AC to DC adapter which would convert 220V AC to 5V DC, on which all our sensors and modules work. The adapter needs to provide constant 5V DC without fluctuations as Raspberry Pi does not have a voltage regulator and can get damaged by high voltage.

Pulse Oximeter Heart Rate Sensor (MAX30100)

The MAX30100 is an integrated pulse oximetry and heart rate monitor sensor solution. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals. The MAX30100 operates from 1.8V and 3.3V power supplies (which can be obtained from Raspberry Pi) and can be powered down through software with negligible standby current, permitting the power supply to always remain connected.

Contactless Temperature Sensor (MLX90614)

The MLX90614 is an Infra-Red thermometer for non- contact temperature measurements. Both the IR sensitive thermopile detector chip and the signal conditioning ASSP are integrated into the same TO-39 can. Thanks to its low noise amplifier, 17-bit ADC, and powerful DSP unit, high accuracy, and resolution of the thermometer are achieved. The thermometer comes factory calibrated with a digital PWM and SMBus (System Management Bus) output. As a standard, the 10-bit PWM is configured to continuously transmit the measured temperature in the range of -20...120°C, with an output resolution of 0.14°C. The factory default PORT setting is SMBus.

OLED Display Module

0.96-inch I2C/IIC 128x64 OLED Display Module 4 Pin, White OLED module which can be interfaced with any micro- controller using I2C/IIC protocol. It is having a resolution of 128x64. The package includes a display board, a display, 4 pin male header pre-soldered to board. OLED (Organic Light-Emit-

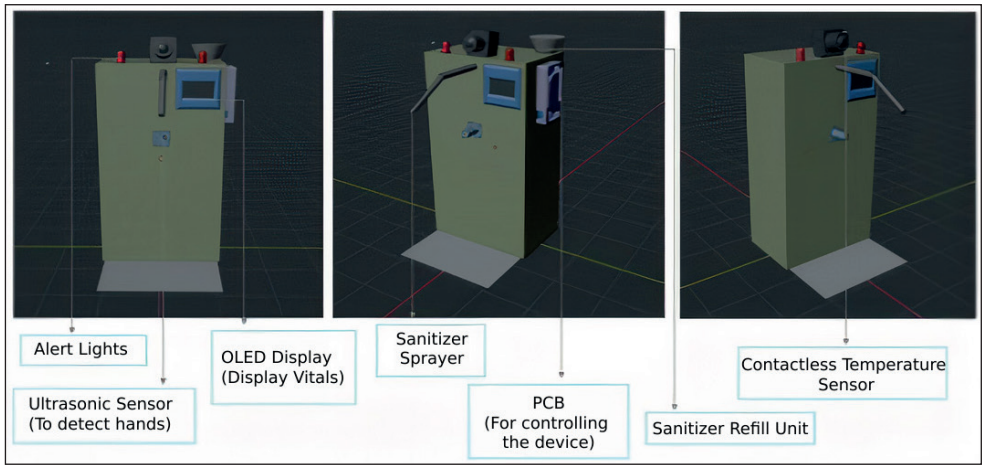

Figure 2. 3D Model.

ting Diode) is a self-light-emitting technology composed of a thin, multi- layered organic film placed between an anode and cathode. In contrast to LCD technology, OLED does not require a backlight. OLED possesses high application potential for virtually all types of displays and is regarded as the ultimate technology for the next generation of flat-panel displays.

Ultrasonic Distance Sensor

Ultrasonic distance sensor determines the distance to an object by measuring the time taken by the sound to reflect from that object. The frequency of the sound is somewhere in the range of ultrasound, this ensures a more concentrated direction of the sound wave because sound at higher frequency dissipates less in the environment. A typical ultrasonic distance sensor consists of two membranes. One membrane produces sound, another catches reflected echo. They are a speaker and a microphone. The sound generator generates short (the length is a couple of periods) ultrasonic impulses and triggers the timer. The second membrane registers the arrival of the sound impulse and stops the timer. From the speed formula, it is possible to calculate the distance traveled by the sound. The distance to the object is half of the distance traveled by the sound wave.

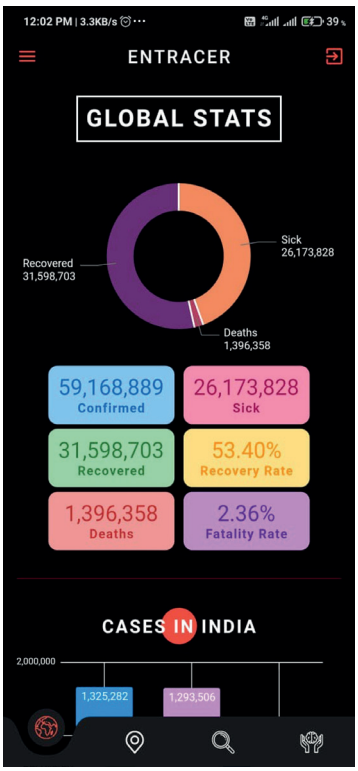

Figure 3. App homepage.

Electrically Actuated Spray Nozzle

The electric hydro pulse nozzle has an integrated solenoid valve to rapidly regulate the on-off cycle of the nozzle. The solenoid valve is positioned inside the nozzle so that it is very close to the orifice. This means the reaction time of the shut-off system is incredibly fast. The nozzle can be cycled off and on up to 150 times per second. This will be used to disperse Sanitizer liquid in an aerosol form whenever the hand is placed under the ultrasonic sensor.

App interface

The Application not only serves as an excellent mean to locally retrieve important metrics such as temperature and oxygen saturation for detecting COVID-19 risk probability unlike existing solutions relying on surveys and manually updated databases, but also helps campuses and organizations to monitor employee/ student health with ease. Since the application is built completely on Flutter (A cross-platform language), hence it can easily be converted to work for both Android and iOS, with a few minor changes.

User Interface of App

Home

The Home screen shows the global statistics about COVID-19 which are updated on a real time basis (Figure 3). These statistics include: Total Confirmed Cases; Total Active Cases; Total Recovered Cases; Total Deaths; Recovery and Fatality rate.

Location Tracing

This screen shows a plot of COVID-19 cases on a map, with major pointers indicating landmarks with the essential data such as Confirmed Cases, Deaths and Recoveries (Figure 4).

Contact tracer

The main functionality of the application sits on this page (Figure 5). It detects Contact Traces with temperature and oxygen saturation readings received from the Data-Accumulation device. The following data is visible whenever a user logs in:

- Roll No./ID;
- Last Measured Temperature Readings;
- Last Measured Oxygen Saturation Levels;
- User COVID-19 Status.

Figure 4. Location tracking.

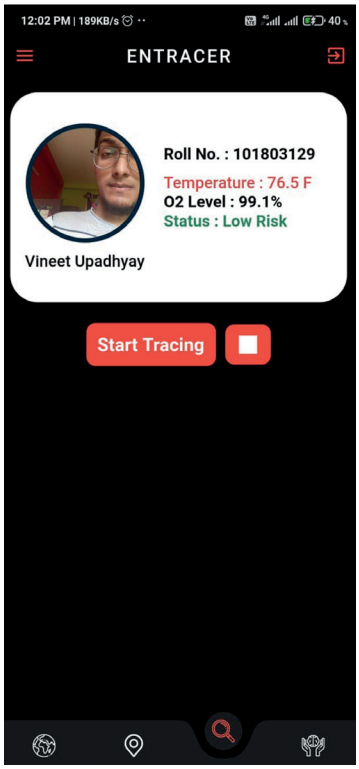

Figure 5. Personal details.

COVID-19 Prevention and Advice

This screen displays WHO-recommended precautions for COVID-19 along with a few FAQs and myths about COVID-19 in the form of "Myth-Busters" (Figure 6).

Working

The functioning of the Device is based on the concept of embedded systems. Raspberry Pi is used for the overall functioning of the device. Various sensors are connected to the Pi to fulfil the circuit requirements. When a person comes in front of the device, the camera recognizes the face using OpenCV algorithms utilizing hair-cascades for facial mask detection, an alarm is triggered if a person is not wearing the mask and is stopped after the person puts on the mask. Then a person puts his/her finger on the blood oxygen sensor, the code starts functioning, and first the person's body oxygen level is measured (this is done using MAX30100 sensor), and an RGB light beside the sensor lights up red to indicate that oxygen level is being measured. After the oxygen level is calculated using the module, this data is sent to the raspberry pi using i2c protocol (the light turns green) and then the person's body temperature is measured. During this process, contact-less temperature screening of the person is done. It's carried out using MLX90164 IR Thermometer which can measure the body temperature without any contact. Just like with oxygen level, all the data is sent to the Raspberry Pi using the i2c protocol. The person can see his levels on the OLED display. If a person with a high tem-

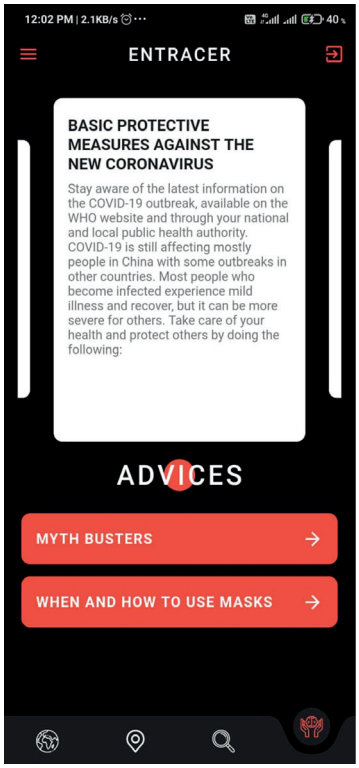

Figure 6. COVID-19 advice page.

perature or low oxygen level is detected, an alarm along with alert lights get activated. A person with a high temperature may be a potential COVID-19 infection carrier; hence the details of such individuals must be stored and shared with the Health Department as a precautionary measure so that they can be tracked and traced if found COVID-19 positive. The details stored will be beneficial for contact tracing purposes as well.

A person who is detected to have a high risk of COVID-19 is advised to get tested and maintain self-isolation until the result of their test arrives. Their data is also sent to the database which is used to track them and alert the authorities and all the people who meet him/her if the person does not obey the social distancing and self-isolation rules.

The vitals of a person can also be entered using the Website, wherein the attendant/guard present at the entry point can input the data to the website via smartphone. Another way of data retrieval of such high-risk individuals can be done using a barcode scanner, which is compatible with most of the ID cards, Aadhaar Cards, etc. These are the two contact-less detail retrieval methods that can be used to get the details of the people with high temperatures.

Now that the person is allowed to pass, he/she puts their hands under the nozzle, which has a distance sensor attached near it and gets activated when a person puts their hands under the nozzle and disperse sanitizer to the person's hands. After this, the person leaves.

The website is divided into 3 sections, each consists of a form to cater to a different category of persons.

The first section is for an outsider who is on a short-term visit to the campus. The website will collect details including the name of the person, the address of the person, the reason for the visit, and which are the temperature and oximeter readings obtained through the automatic sanitization device. This information will be stored securely on a central database which will be both used by the app and the website.

The second section is for students who do not have the app installed on their phone or for any reason cannot be tracked by the app. The website collects their roll number, hostel details, name, and place of visit along with the temperature and oximeter readings obtained through the automatic sanitization device. These details will be stored in the database.

The third section is for staff who do not reside on the campus. The website collects their ID, name, residence address, which block he/she will visit along with the temperature and oximeter readings obtained through the automatic sanitization device. These details will be stored in the database. These details will be overwritten if that particular student/teacher/guest visits any block/building and enters the same details and his/her most recent temperature and oximeter reading will be saved. This ensures that we'll always have the most recent data and thus help in robust contact tracing.

The website also has an admin interface that allows the administrator to monitor the database, analyze trends, and add more users, change the password, and delete users.

The Application utilizes the BLE (Bluetooth Low Energy) signals for contact detection. The idea behind using BLE signals is that normal Bluetooth signals are resource-hungry and might be dismissed in lower-end smartphones as a power-saving feature. Moreover, by using such signals, we can easily broadcast and receive broadcasts from any device using the application nearby. This leads to precise contact-detection when combined with GPS signals.

Using the data accumulated by the Entracer Sanitization and Data Accumulation Device, the users are stacked into the following categories based on their temperature readings: High Risk or Low Risk. Every time, the user starts tracing, the app creates a unique Bluetooth signature, discoverable to all BLE (Bluetooth Low Energy) devices. This signature is readable by all devices nearby with the app installed.

As soon as a user comes in contact with another user, his Bluetooth signature is received. Upon receiving the Bluetooth signature, the application automatically finds out the User ID and the corresponding details (Temperature, SpO2, Status) and saves a reference with the time of contact, along with the location of the contact.

This reference is saved to the database and displayed to the user on his smartphone. The references are kept and displayed till a 14-day "no-contact" period is established.

RESULTS

This device makes the entire process of sanitization and COVID-19 screening rapid, easier, and cost-effective as well. It also solves the problem of not having a common database of people and helps automate the monitoring process.

Since the device measures blood oxygen levels and body temperature, which are not just COVID-19 specific, this device can be used even after the coronavirus pandemic subsides to monitor the general health of people in public places or for a company to monitor the health of its employees on campus.

The device is highly versatile and compatible for all types of environments and public places. The reason for its compatibility is that it is small [35cm (h) X 25 cm (w) X 20 cm (d)], can be easily mounted anywhere, doesn't require much human interference for its regular functioning. It takes approximately 30 s for the entire process per person and can screen and sanitize 600 people in one refill which makes the pass-through rapid.

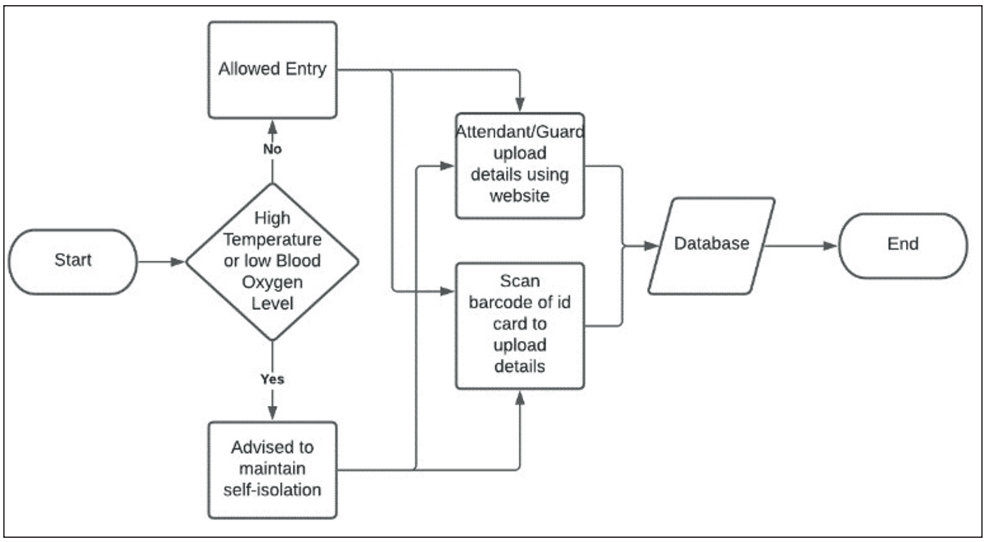

Figure 7. Flowchart for data entry.

Multiple such devices can be installed at places where there is higher public mobility, for example, railway, metro, bus stations, etc.

Ecosystem

All three sub-parts of our idea, the device, the website, and the app seamlessly communicate with each other to create an ecosystem for monitoring the vital signs of people.

The device sends all the readings to a common database, from that database the app takes the data of each person and displays it on their phone. Data can also be entered through the website and is sent to the same database and after that, it is essentially the same as the data sent from the device.

The website can also be used by authorities to view and monitor the vitals of all its employees/ members. This system will prevent the entry of suspect cases to public places and will be helpful for contact tracing which will eventually improve the prevention of infection spread (Figure 7).

DISCUSSION

The device's compatibility with most of the public places makes it a highly scalable model to implement. This device is not location specific and can be installed anywhere where proper hygiene needs to be maintained. The comprehensive and smart features which come along with the device lead to a fast-paced precautionary procedure which can lower the chances of infection spread significantly. The current literature on this topic and related devices available in the market have some of these features but no device provides all the features provided by this device with the ecosystem. Commercially available devices provide sanitization and temperature monitoring, but no device provides an ecosystem for real-time tracing and prediction. By using this device, the goal for increased sanitation in public places can be achieved and this tool along with its robust ecosystem can help significantly in maintaining social distancing and reducing the increasing number of COVID-19 cases.

CONCLUSIONS

There is an urgent need in the market for devices that can identify potential COVID-19 cases as due to the spread of the virus, it is next to impossible to test everyone, so we need to find a way to prioritize the testing process. Our device can provide reliable data which will help in speeding up the isolation process for potential patients who can infect others.

The market for touch-less technology-based devices is also emerging rapidly. There is an urgent need for sanitizing devices with minimal or no contact to pre- vent transmission of germs from an infected to a healthy person. By using the Automated Sanitization, required hygiene compliances can be ensured and this device will also encourage hand hygiene[7], which will eventually lower infection spread and prevent the entry of suspect cases to public areas by alerting the authorities during the contactless temperature screening procedure if the person has high body temperature. This device can be extremely useful for complying with good hygiene standards at any place.

Conflict of Interest:
The authors declare no conflict of interest

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