Contactless IoT based Smart Rooms for COVID-19 Safety Monitoring and Control

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Abstract: The spread of Coronavirus (COVID-19) led to the closure of educational and economic institutions. The virus can easily infect a person through direct, indirect, or close contact with an infected person. To control the spread of COVID-19 there is a need for early identification and better cleanliness. For regaining of socio-economic activities as earlier, technology would have a significant act, to ensure the safety of the people and to manage the disease, a need for smart rooms is required where people come together to study and work. In this paper, an effort has been made to create a smart room model that can maintain social distancing, mask detection, hand sanitization, and contactless attendance where this system can be implemented in places like schools, universities, offices, etc. Furthermore, the proposed model can be utilized in times of similar outbreaks of diseases.

Keywords **- COVID-19, Internet of Things, Smart Rooms, RFID, Mask Detection, Social Distancing, Automatic Sanitiser Dispenser**

Introduction

The outbreak of COVID-19 forced many governments to lockdown their countries to reduce the spread of the virus. The coronavirus was mentioned as a global pandemic by the World Health Organization (WHO) on March 11, 2020. Symptoms formed by an infected person consisting of fever, cough, nasal congestion, fatigue, and other signs of upper respiratory tract infections [1-3]. Through direct or indirect contact with an infected person, the virus can easily pass on to another person thus creating an outbreak [4-5]. Due to the restrictions placed by governing bodies almost all the schools, colleges, businesses, and public places were closed, which directly affected the economy, many countries have seen a fall in growth rates [6]. The virus has infected about 109,432,722 and estimated total fatalities of 2,412,598 individuals as of 14 February 2021, such a catastrophe has not occurred if proper monitoring systems and safety standards were in place [7]. However, positive news on vaccination gives hope to humanity but still, there is a need for smart systems which could be used for the prevention of the disease [8].

Furthermore, the restrictions placed cannot be sustained for the long term as it affects the economy and livelihood of the people, to avoid that there is a need for the opening of businesses and educational institutions in a phased manner. At that time to prevent the spread of disease, people must follow social distancing, need to wear a mask, proper sanitisation, and must reduce unnecessary touching of public places [9-10] and that time some difficulties may be faced. So, this paper confronts the idea of automation in social distancing, mask detection, hand sanitisation, and a contactless attendance system that can be implemented in schools, colleges, offices, etc. The target of the proposed model is to provide a monitoring and safety system that is cost-effective and accurate. Also, the goal of the model is to reduce the spread of coronavirus from a person to another person.

So, this model tries to aim at a reduction in areas where human physical intervention is much needed, from a door handle to the attendance system where everything is automated and even provides safety measures right from the start. So the model works in the following way, when a person comes into the range of a camera that is fixed outside of the office or a classroom with a voice command, the image of the person is captured by the mobile application and detects wearing a mask or not and send signals through the Bluetooth module and display on an LCD screen like, if a person is wearing a mask LCD will display - Mask Ok, Place your hand for Sanitiser and If not, LCD will display - No Mask, Wear a Mask for Entry. Afterwards, it guides the person to a sanitiser dispenser whereby using an ultrasonic sensor, detects the person's palm and a certain amount of sanitiser will be dispensed. Then with a Radio Frequency Identification (RFID) based attendance model, the person will be identified and then automatically the door will be opened for certain seconds and will be closed automatically, and this will continue for every person. In between, there will be a social distancing system while the above process is going on and if the second person tries to intrude or even comes close to the first person, more than the range permitted, then a led will blink to condemn the violation. This will be ensured for a maximum of three members in this model. Importantly the proposed model can be implemented in similar kind of situations in future.

Related Works

As the spread of the COVID-19 pandemic is at an exponential rate, the IoT based safety monitoring and control systems are also in huge demand [11]. The warming up vaccination gives hope still the process takes time, so people must rely on technical solutions to control the transmission rate. Many policymakers started to support technology-based systems for identifying, detecting, and suppressing the rapid transmission of COVID-19. For example, India developed an indigenous application named Arogya Setu, which performed with the help of location for identifying patients in an area which in turn used for making decisions, also informed people about the scenario in that area and provided medical advisories whenever needed [12-13]. In this situation, early identification and prevention are effective practices to avoid the spread of the disease to more people. A recent study shows that the virus can stay on surfaces for more than several hours to days [14]. Prevention of the disease can obtain via social distancing, wearing a mask and through proper sanitisation techniques. Thus, there is a need for technologies that can do the above-mentioned practices in an implied way.

In a similar background, many research works have been conducted on prevention and health monitoring, such as mask detection system with the implementation based on MobileNetV2, a mobile vision application method formed using Convolutional Neural Network (CNN) developed by Google [15]. The study uses two types of datasets, the Kaggle dataset and Real- World Masked Face datasets (RMFD) were used during the process of training, validation and testing so that the model can be applied to the datasets [16]. This system also provided analytical data on the percentage which people without mask which in turn can be used for applying necessary measurements in an area. Through such a model it is possible to accomplish a monitoring system that can be easier to avoid transmission by distinguishing individuals without a face mask. Likewise, a study conducted by Punn et al. [17] suggested an efficient real-time social distancing system that makes use of the deep learning framework YOLO v3 object detection model to identify humans from the background and used deep sort method to trace the marked people with the help of bounding boxes [18]. The mentioned research emphasis that social distancing is a mandatory action to flatten the COVID-19 disease infection curve, but also put forward that accuracy and precision may be a concern and issues like privacy needs to be addressed. In another work, a system developed by Dubey et al. [19] showcased an IoT based non-contact automatic hand sanitiser dispenser that was built with Arduino and an ultrasonic sensor that can be used in need of sanitisation. Although the system is affordable, effective working needs to be validated, also the usage of a non-rechargeable low energy density battery for such a system will be a drawback as there is a need for replacement. A similar paper put together an automatic hand sanitiser system that is compatible with various containers that operate by converting rotary motion to linear motion generated through DC motor, tries to imitate hand pressing effect and uses an infrared sensor for the identification of hand placement [20]. Although the system provides non-vibrating operation there may a chance of lodging in the crank and shaft mechanism while operating. As the proposed implementation of the system in this paper is for institutional endeavours there is a need for an authorisation system for personnel's is required, for that, a radio frequency-based digital attendance system can be used with controlled access [21]. The study makes the application of technologies like Transmission Control Protocol (TCP) and Internet Protocol (IP) for communication and data storage, retrieval of the RFID system [22]. This, in turn, can also be used for recording the entry timing, for calculating time spend and data of related people can be generated with the help of databases.

Furthermore, the proposed model took inspiring concepts from all relevant research works conducted by the researchers. There have been a lot of research work carried out for the implementation of IoT based technology for COVID-19 in detection, monitoring, and safety which in return helping to contain the disease. But very few of those works attempted to combine all in the need for a necessary system required for the safety features and in controlling of the disease. So, in this paper, the model, in turn, tries to combine all the systems for fulfilling protocols for COVID-19 safety and similar kind of outbreaks in future.

Materials and Methods

The proposed model for COVID-19 safety and control in institutional endeavours operation has been divided into five tiers named social distancing, mask detection, hand sanitisation, attendance system and door opening which is integrated with a combination of Internet of Things (IoT) features and connectivity such as Wireless Fidelity (Wi-Fi), Bluetooth and RFID. These five tiers will be able to fulfil the ultimate objective of the system, to put an end to the spread of coronavirus through human transmission.

Besides, the data passes through the model as four layers- Sensing, Transmitting, Processing and Output. So, the layers collect data and identify the person moving in the system and act according to the gesture. For example, when a person places his hand for sanitiser the ultrasonic sensor identifies it, and the microcontroller board grabs the data for sanitiser dispensing. The proposed system tiers work in asymmetric communication where one device controls one or more devices and serves as the communication hub, moreover like a master and slave integration and Arduino mega microcontroller being used as a master device. Arduino microcontroller boards are used in the implementation, which is an open-source single-board microcontroller it has an Atmel Atmega328p processor and on-board input/output support. The software mainly consists of a boot loader and standard program language compiler that runs on the board [21].

In the framework, the first thing a person has to follow is social distancing and which will be controlled with the use of laser diode and photoresistors, moving forward when the turn comes the person have to appear for mask detection with the help of a smartphone and voice command after successful attempt the person have to sanitise their hands from the automatic sanitiser dispenser which is made with an ultrasonic sensor for identification of the hand. In the last phase, the person has to identify with the assigned RFID tag which has to place on the reader for identification. After successful identification, the door will be opened automatically. The block diagram **Figure 1** below represents a basic overview of the proposed model.

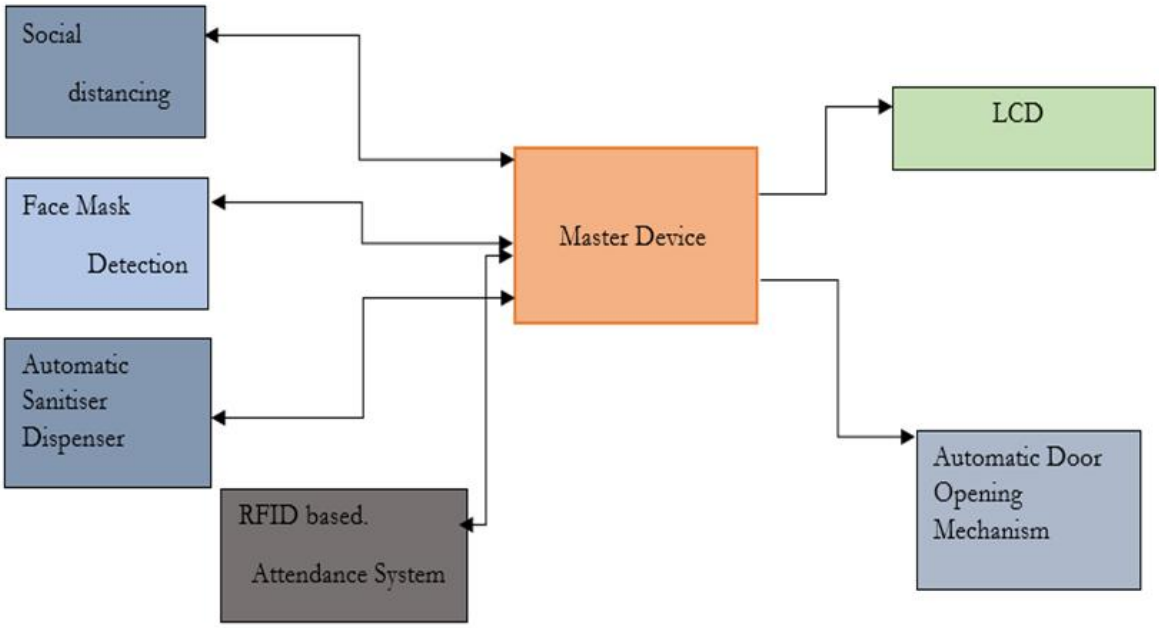

Figure 1 Block diagram representing the proposed model.

1. Social Distancing

In this part, people are supposed to stand in the appropriate position which is at least one meter away from each other, this distance can be changed according to the need. If the person does not stand in the proper place, the person will be notified by using an indicator LED and a beep sound to follow the distancing properly. For identifying, Laser diodes and Photoresistors are used, the photoresistor is also known as a Light-Dependent Resistor (LDR) which is a passive component that decreases resistance with an increase in light on the sensitive area. The laser diodes are placed facing the photoresistors such that the laser diode will shine directly on the photoresistor surface when it is switched on. The person must stand in a position such that it blocks the laser beam and if the person is moved from the position and the laser is not blocked, then the slot is no longer occupied, and an indication of LED and a beep sound will be there for three seconds showing that the person is moved or not following the distancing.

2. Mask Detection

The face mask recognition in this model is made possible through thunkable, an online application building platform. For detection of mask-wearing or the image classification method is put together using an external Application Programming Interfacing (API) with a machine algorithm. The

face mask detection API named Maskerizer is a cross browsers REST API (Representational State Transfer) that gets an input with a still photo and returns a string that contains predictions with a certain amount of probability. The API which gets a JavaScript Object Notation (JSON) input with a still photo or a Unique Resource Locator (URL) of the image and returns a JSON string that contains predictions with a certain amount of probability filtered for output with a minimum of 50%, bounding boxes of detected face mask put on human faces in a correct way covering both the nose and the mouth with its top, left, width, height values and, if required, for each prediction, a bounding Box Photo as base64 encoded string of the detected face mask can be stored [23-24]. The bounding box contour colour will be Green if the detected face mask is put on in a correct way covering both the nose and the mouth and red if the mask is not used. So, when a person comes into the range of a mobile camera that is placed outside of the room, with a voice command by the person the image will be captured by the application and it analyses that whether the person is put on a mask or not and sends signals through the Bluetooth module for indicating the output on LCD. if a person is wearing a mask LCD will display "Mask Ok, place your Hand for Sanitiser" and If not, LCD will display "No Mask, Wear a Mask for Entry".

3. Automatic Hand Sanitiser Dispenser

The automatic hand sanitiser works by using an ultrasonic sensor, a microcontroller, and a servo motor. The ultrasonic sensor is used to check the presence of hands below the outlet of the sanitiser dispenser. It will continuously calculate the distance between the sanitiser outlet and hand and sends a signal to the microcontroller board-Arduino to turn on the servo whenever the distance is less than 15 cm to pull the sanitiser out (**Figure 3**). A mini servo motor is used for the pumping action. So, the servo motor is placed vertically on the pump and when the hand presence is detected the servo will turn 90 degrees for dispensing and then turn back to the original position for the next dispensing of the sanitiser. In **Figure 2** the block diagram shows the data flow through the model. After that, the LCD will display to place the RFID card for authorisation of the person.

Figure 2 Block diagram showing the working method of automatic hand sanitiser dispenser.

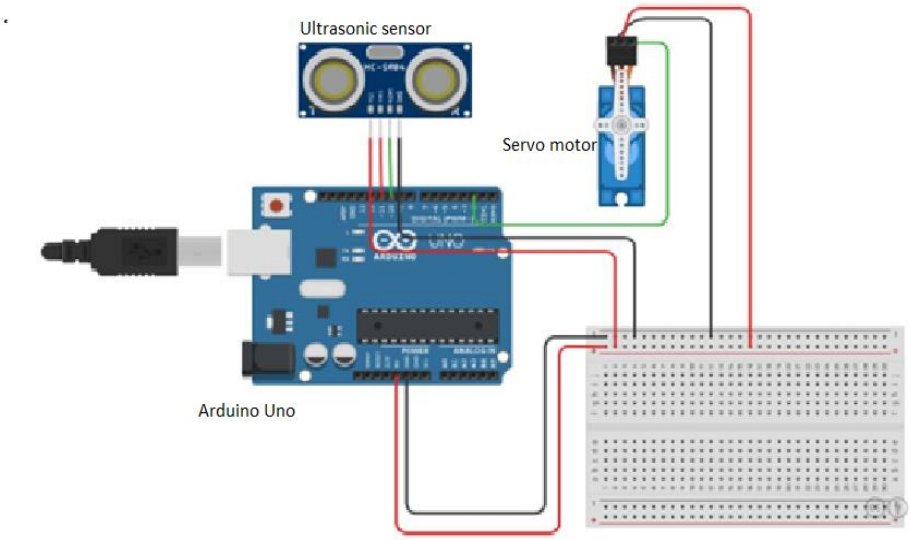

Figure 3 Simulated Circuit diagram of hand sanitiser dispenser.

4. RFID based Attendance system.

This stage uses Radio-frequency Identification or RFID technology for the automatic marking of attendance and identification, with a combination of Wi-Fi and database. So, the RFID technology makes use of electromagnetic fields and it consists of two parts- RFID reader and RFID tag. The RFID reader repeatedly sends radio waves of a specific frequency so that when a tag is within the reach of these radio waves, the tag can send the feedback to the reader and depend upon that feedback the reader identifies the person. In **Figure 4** the connection of the reader to the microcontroller board is shown. There are three kinds of RFID tags available that is passive, semi-passive, and active tags [25-26]. For this model, passive tags have been used. Passive tags get their potential from the incoming radio waves. The operation frequency of the RFID in this model is 125 kHz which is a low-frequency band and has a range of 10 cm. Upon successful reading, the microcontroller will send a signal to the database through the Wi-Fi module, which in turn mark the attendance of the person and show the relevant identification details on the LCD. The local database is made possible through XAMPP, an open-source multiplatform web server solution developed by apache friends. MySQL, a Structured Query Language (SQL) is used for adding, accessing, and organising content in the database like a person id, name, entry time, etc. and a PHP page is used to update the database content like entry time.

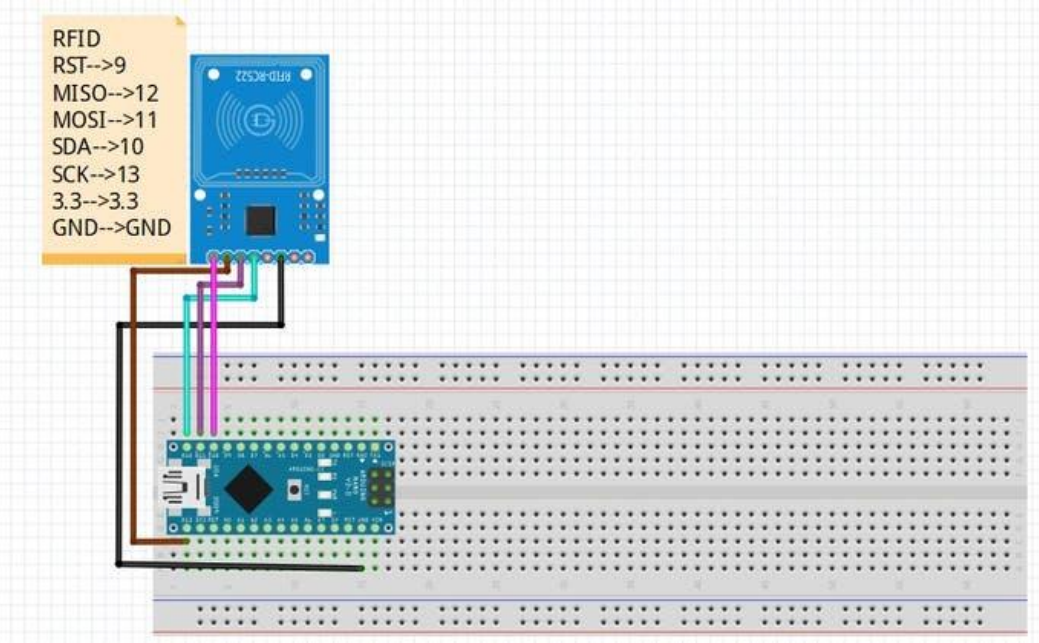

Figure 4 Simulated circuit diagram of RFID reader connection to Arduino Nano.

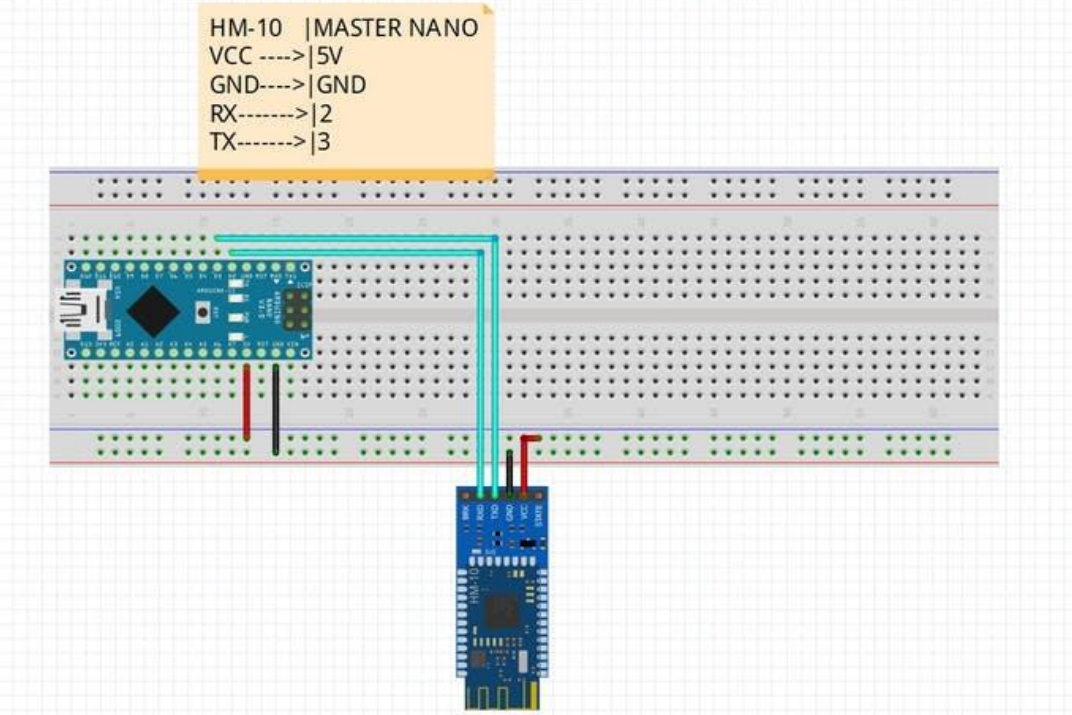

Figure 5 Simulated circuit diagram of Bluetooth Module (HM-10) connection to Arduino Nano.

After the successful identification through RFID, the door will be opened automatically. The model uses a Bluetooth module, Arduino Nano, motors, and motor drivers. As shown in the **Figure 1** block diagram the master board sends a signal to the Arduino Nano (slave) for activation of the model through Bluetooth module, upon that the motor driver will be enabled and the door will be opened with the help of high torque motors. The function of the motor driver is to act as an interface between the motor and the control circuits.

Results and discussions

A better way to prevent the disease from spreading is early identification through symptoms. The proposed IoT based model has been structured in such a way that it can help to maintain various basic measures for the prevention of COVID-19. However, because of the devices that are linked together, the model can face many challenges during implementation, such as connectivity and hardware interfacing issues. In face mask detection, the model uses an API that needs a network to identify and compare the image. Similarly, the RFID also communicate to the database through the network, so an error or interferences in the node can cause issues in the operation. While interfacing the model must follow different protocols such as serial peripheral interface, for multiple modules which may affect the performance of the model.

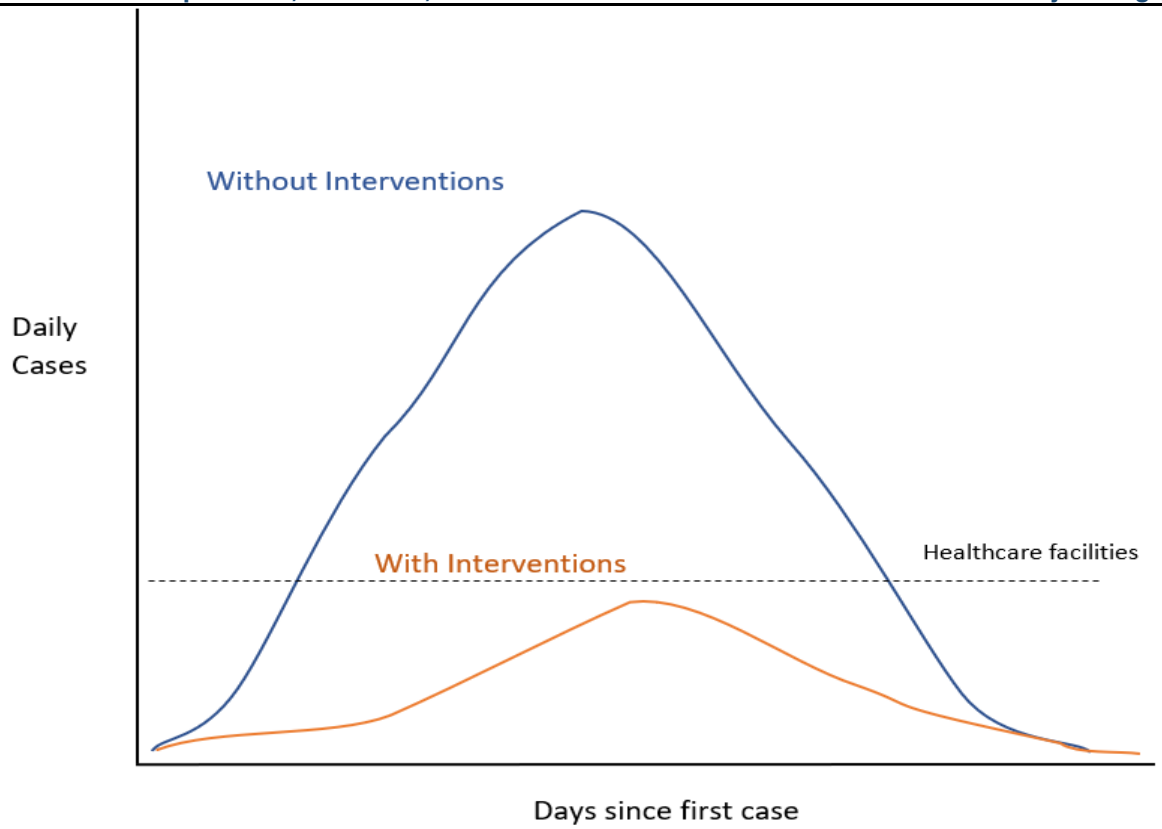

Figure 6 Desired outcome of safety measures for COVID-19 with interventions. Adapted from corresponding diagram in the European Centre for Disease Prevention and Control (ECDC) technical guide [27].

Also, despite being in the middle of technological advancement and progress, a microscopic virus has been clobbered the livelihood of millions of people around the globe and the well-structured system of the economy has toppled well-nigh ever since. Mankind desperately failed to shackle the contagion of the virus at one stage which caused one of the worst nightmares ever had in the last century. But the use of safety measures can help to minimise the number of individuals who become infected and reduce the need for medical attention because of the COVID-19 pandemic. **Figure 6** indicates that the proper safety measures help to curb the rate of infection and the reduced peak will help the burden on the healthcare structure to give proper facilities to the people who are fighting against coronavirus and that is the purpose of the proposed model.

People often get infected through aerosols (small respiratory droplets) in nearby areas or while communicating with others, recent studies show that wearing a mask can significantly reduce the emission of the particle by 90% which in turn can reduce the transmission of the disease [28-29]. **Figure 7** shows the average accuracy of the mask detection software used in this model with different light conditions, the data is collected by comparing 5 images with and without masks at low, enough, and good natural lighting with a mid-range phone camera. The results showed that the model gave better results – 93% with mask and 95% without a mask at good lighting conditions.

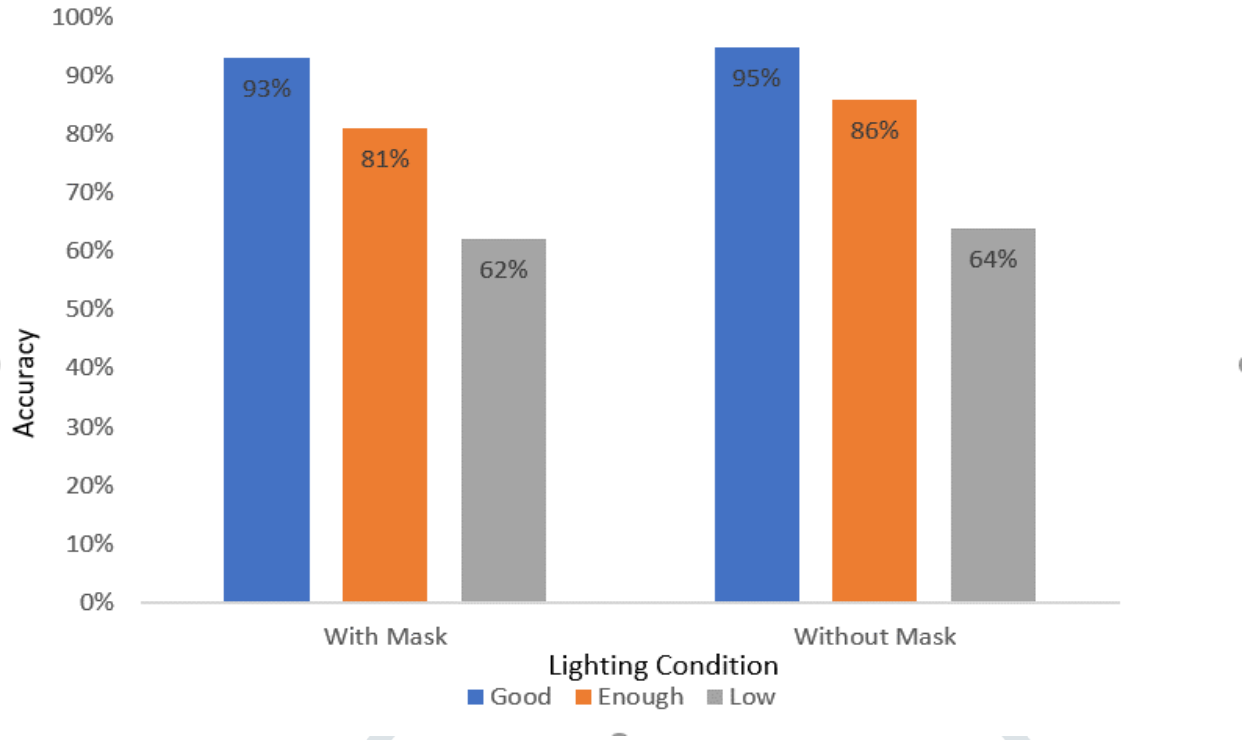

Figure 7 Accuracy of the mask detection in different light conditions.

Another interesting factor was the time taken (**Figure 8**) to complete the steps which are normally less than 80 seconds, and the maximum time can go more than 200 seconds. This is mainly because of the social distancing part where one person has to wait for the completion of a task by other people in front of him and the time can depend upon the number of people are available in the queue. Secondly, the mask detection can also take time as it has to rely on an online API to validate the image.

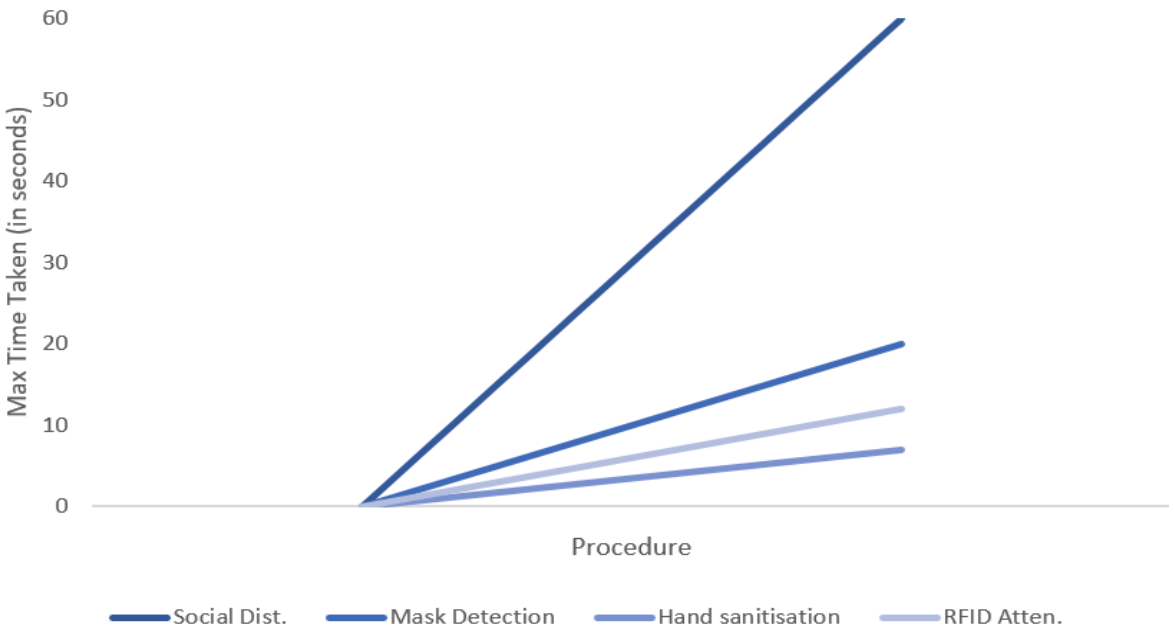

Figure 8 Maximum time taken for following the procedure.

Conclusion

The proposed model can be used for building a low-cost, high-efficiency health monitoring system that can be implemented in educational institutions and office spaces. The model tries to ensure that the people

were following norms like social distance, wearing a mask, sanitisation, etc... The restrictions imposed by regulatory bodies cannot be preserved for the long run, as they impact the economy and people's lives. So, in a phased manner the institutions must open at that time the model would be much convenient. As the latest issues nowadays, that happened around the world is the spreading of new variants of coronavirus, made so much attention and discussions among people. However, a better way to prevent the disease from spreading is early identification through symptoms. In conclusion, the procedures, which provide an assortment of ways in safety monitoring and control of coronavirus, give an astonishing promise and potential to fulfil the demands from the health management systems.

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