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IoT Based Automated Entry System for Covid Prevention: A Review

Smita Nayak[1], Sudarshan Srinivasan[2], Abhishek Padiya[3], Prof. Sushma Kadge[4]
[1, 2, 3]*Electronic Engineering, K.J. Somaiya College of Engineering, Mumbai, India*
[4]*Professor in Department of Electronics Engineering, K. J. Somaiya College of Engineering)*

Abstract: ***Since the onset of Covid-19 pandemic, a disease caused by SARS-CoV-2, there has been a significant rise in the research and development for various technologies for the prevention of the pandemic from spreading further. Many technologies like Face Mask Recognition, Facial Recognition, Non-Contact Temperature Measurement, Non-Contact SPO2 measurement systems have been developed with significant quality and efficiency. This paper discusses the results of some of the research done in the same field.***
Keywords*: Facial recognition, Mask Detection, Temperature Measurement, Deep Learning, Convolutional Neural Networks, Sanitizer system, SPO2 measurement, Image Processing.***

I. INTRODUCTION

After the outbreak of the dangerous new flu-like infectious respiratory disease SARS-Cov-2 virus causes COVID-19 (also known as coronavirus), billions of lives were at stake globally. This disease was generally getting spread through respiratory droplets from symptomatic persons but later discovered that it can also be transmitted from asymptomatic persons also. This led to the rise of some special rules, often called as Standard Operating Procedures(SOPs) which involved social distancing, wearing masks and being quarantined in case of any symptoms, etc. These were followed to some extent in High-Standard Offices but due to economic breakdown, small businesses often could not afford the staff to comply with these rules. This contributed significantly in allowing the diseases to spread to various places. This called for automated systems which could allow entry to only those persons who comply with the rules and at the same time are cost-effective and efficient enough. These have been helpful to some extent in controlling the spread of the disease. Various techniques are implemented and embedded in these systems. Some of the most important and widespread techniques are Facial and Mask Detection, Non-Contact Temperature Measurement, Non-Invasive SPO2 Measurement, Automatic hand Sanitizer Systems and Remote Monitoring of these systems through web-based dashboards involving IoT at its backend. Face Mask Detection System is an offset of Object Detection System which incorporates Deep Convolutional Neural Networks(CNNs) to provide better accurate results in recognising identities of persons with masks. Primary objective of these systems is to check whether the person is wearing masks or not and also to correctly recognise the identity of the persons with masks with sufficiently required databases. Non-Contact Temperature Measurement Systems often use Infrared-based Thermal Cameras which detect elevations in Body Surface Temperature values mainly of Face. This is often done incorporating AI with real-time monitoring systems at the backend. Upon detecting any said elevations of a person's temperature, the system sends alert signals to authorized personnel in charge of monitoring the system. This, too, contributed greatly to the disease's control and eventual reduction in the number of cases. Non-invasive SPO2 measurement devices can be made in two ways. The first is to employ a digital camera to extract signals using the imaging PhotoPlethysmography (iPPG) method. Afterwards various signal processing techniques are implemented to deduct the SPO2 value. This is undoubtedly an efficient way of measurement as it does not require the person to be fitted with a fixed measurement system but not much developed and the current systems need the person to be in a stationary position. Second method of measurement is using IR sensors which detect the pulses of blood flow from a person's finger. Though non-invasive but it needs to have contact with the person's finger to detect the minute pulses. Then implementing appropriate algorithms, the SPO2 levels of a person can be estimated. This currently is a more proven technique and quite developed with near exact and reliable output. Other systems like automatic hand sanitizer systems and remote-monitoring of the systems' observations through databases and dashboards further enhances in restricting the spread of the so-discussed disease.

More and more research and developments are taking place in this very instant which pave the way for completely eradicating this disease and also providing a means of safety and clean environment which can reduce the chances of new disease to spread easily. For making life on Earth more safe and secure. Furthermore, this paper provides the detailed analysis observed in various research papers in the same field and summarized them in a more understanding manner.

II. LITERATURE REVIEW

The table given below represents the review of various papers. These papers focus on parameters such as mask detection, temperature scanning, oxygen level measurements, authorized entry and database management. Several comparisons can be established between the papers for selection of an appropriate and a cost effective design.

Table 1: Detailed findings of various technologies

SR. NO.	TITLE/AUTHOR	YEAR	DESCRIPTION
1		2014	The author implements a compact, cost-effective and low-power Health-Monitoring system which monitors Body Temperature and Pulse Oximetry(SPO2) and also sends this data to the doctors so they can remotely monitor all their patients. SimpliciTi protocol is used for wireless communication which uses low-power radio frequencies targeting small RF networks. Future scope is provided as implementing using 4G communication protocols to increase data transfer rate.
2		2015	The authors project implements a Patient Health-Monitoring System which measures and monitors various biological parameters like heart rate, SpO2 and Temperature. The various components used are Infrared LED for Heart-Rate and SPO2 measurement & LM35 for temperature Measurement. Data is monitored wirelessly using a web server and android application which uses Bluetooth module as it consumes low-power and ThingSpeak as Web-Server. .
3		2017	The study proposes a non-contact temperature algorithm using thermography analysis. Viola-Jones algorithm is used on the best frame from the video sequence which shows the best face features(Haar-features like nose, etc.) and temperature is measured from that frame using FLIR and low-cost CP-cosmic IR camera. The difference between this technique and the physical thermometer lies in the range of 3.46-4.6 degree Celsius.
4		2019	The paper implemented a technique to detect the forehead surface temperature using a series of images as video and using Thermal Face Detection(MobileNet-SSD), ROI Location and Face Tracking(Kernel Correlation Filter) to identify face and raw value of body surface temperature from which Face temperature value is calculated after calibration. This is done using FLIR Lepton2.5 breakout board and NVIDIA JETSON TX2 and Mean Absolute Error and Root-Mean-Squared values are found out to be 0.375 and 0.439 respectively.
5		2020	The study observed provides an efficient and cost effective automatic hand sanitizer system as there is no micro-controller in use. Also by emitting IR waves at specific frequency and using a frequency specific IR receiver, the effects of sunlight had been eliminated. The overall cost of the system was 457 Rupees.
6		2020	The authors documented an analysis of a hand sanitizer system based on Low-Energy Bluetooth technology equipped dispenser which is coupled with Android phones to allow only the health-care worker to use it by tracking their proximity to the dispenser. This is to avoid the casualty of patients ingesting the sanitizer. Moreover, the hand sanitizing records are maintained through a web-based dashboard. The main component used is LightBlue Bean. This system is best suited in

			Hospitals and care-centres.
7		2020	The authors designed a highly cost-effective and simple hand sanitizer system without the use of microcontrollers. The components used are IR sensor, battery and passive components providing a RC time delay to control the dispenser pump motor. LEDs are used to indicate the battery status. The overall cost of the system is 500 Rupees.
8		2020	The paper implemented an IoT-based system for Covid protection. The various solutions implemented were Temperature Measurement using MLX90614 sensor or Thermal Camera sensor, Mask Detection and Social DIstancing Check using OpenCV's Haar Cascade Classifier. A database is maintained(MQTT protocol) and accessible through the Security guards' android phone. Alert signals with location are notified to the security guard so necessary action can be taken. The accuracies of Mask Detection, Social Distancing Check and Temperature Measurement are 84-91%, 65-73%, 0.5^{o}C (IR) & 2.5^{o}C (Thermal Camera) respectively.
9		2020	The authors implemented an IoT-based Autonomous System to monitor users from Covid-19. The system uses Thermal Sensor for Temperature Measurement, Highly-zoomed camera for QR-scanning, LED screen to display results, proximity sensor to detect motion and speaker for voice communication. Users having smartphone are scanned with QR and others are provided an UID through which they can get their QR after entering it. The details of users(name, age, gender and mobile number) are then managed through an IoT dashboard providing easiness to track them.
10		2020	The study introduces an IoT-assisted Smart Hand Sanitizer that can effectively sanitise hands. Temperature sensor, ambient temperature humidity sensor, ultrasonic sensor, liquid state detector, hand dryer, and nodeMCU to record data at ThingSpeak cloud were all part of the system. It automatically collects data such as ambient humidity and people's body temperatures, as well as monitoring the liquid stage (or level) of sanitizer and the device's geographical location in relation to the server.
11		2020	The authors have built and developed software for patients which does Facial Recognition and Temperature Measurement and simultaneously recording the data in a database. EmguCV library and Viola-Jones method was used for Facial Recognition, MLX90614 sensor for temperature measurement and .NET framework for Database Handling. The microcontroller is ATMega and code is written in C#. The efficiency of the system came up to be 72% while it gives 82% in boosted mode(additional 5 images per face taken).
12		2020	The paper develops a method that improves detection performance and is ideal for real-time mask detection, particularly in the dark. It tends to produce state-of-the-art results in all object detection applications and can instantly assess whether or not pedestrians in public settings are wearing a face mask. CSPDarknet19 is used for object detection alongwith YOLOv4 and PANnet is used for supervision.
13		2020	The study developed a SOP Compliance and Monitoring System for small retail enterprises. It detects not only the distance between

			consumers but also between the counter and the consumers. It warns the individuals on violation of any of these two. IR obstacle sensor is used at the entrance to count the number of entering and exiting, Time of Flight sensor(VLX531x) ensures minimum distance at the counter and a wide-range camera with Rpi measures distances between individuals. MLX90614 sensor is used at the entrance for consumers to enter their temperature in the questionnaire provided.
14		2020	The theory presented in this paper is to build a low-cost, high-efficiency system that operates without the need for human interaction. The system has a PIR sensor for detecting the presence of individuals and a temperature sensor(TMP36). Upon detection of safe temperature level, the individual is then sent through a Sanitization tunnel which cleans and sanitizes the individuals throughout. The buzzer sounds if any violation is detected. The authors claim the system to be 100% accurate.
15		2020	The technique executed in this paper creates a low-cost sanitization system capable of sanitising 600 persons every day. As soon as a person arrives, hand automation sanitization begins, followed by contactless temperature scanning. The authors intend to host a website for database maintenance in the future.
16		2021	The study provided the analysis of non-contact SPO2 measurement using a computer-vision based system on the basis of imaging Photoplethysmography(iPPG). The iPPG signal obtained from the ref and green channels is further decomposed into signals of different frequencies and later SPO2 is estimated using the optical properties obtained from these signals. This technique proved effective in the preliminary tests so far.
17		2021	The paper proposed a way to use LDR sensors with laser light to detect the blockage due to human hand, also eliminating problems faced by IR and ultrasonic sensor. The system also sends alert signals when the sanitizer liquid level drops below certain level in the container.
18		2021	The authors have developed a real-time embedded system for Automatic Mask Detection which also has Facial Recognition and Temperature Measurement. An attendance database is recorded automatically and is also sent to respective parents along with the temperature recordings. CNN model with OpenCV is used for Mask Detection, IR sensor for Temperature Measurement and Features of face like Eye, Nose, Eye-Brows, Mouth, Skin Tone, Hair Color,etc using OpenCV is used for Facial Recognition. This system is best suitable for school and other educational institutions.
19		2021	The paper implements a Hand Sanitizer System which has AI-based Mask Detection using Machine Learning and Deep Learning using OpenCV, Thermal Scanning using Thermophile sensor and Hand Sanitizer using Ultrasonic sensor. An AI camera is used for mask detection which has integrated Automatic Scene recognition, auto-adjustment for better quality, can combine HDR images and also switch to various modes upon requirement. The main microcontroller is Raspberry Pi and the Entry is given only upon meeting the set conditions of the system.

20		2021	The authors designed an Automated System having Temperature and Mask Detection. The system uses an AI-enabled IR-sensor Camera which also detects temperature. The system also MQTT protocol and sends data to the smartphones of the guards of the organization. Mask detection has been carried out using OpenCV and Haar-Classifiers. The advantage of this system is being able to detect for multiple users(max 10) at a time. The accuracies of mask detection and temperature measurement are 84-95% and 0.5-0.9^{o}C.
21		2021	The paper has implemented a cost effective system which has Mask Detection, Temperature Measurement and also provides Sanitization. The requirements of this system are CNN, OpenCV, MobileNetV2, Tensorflow, Keras and other libraries for Mask Detection, I2C enabled temperature sensor for Temperature Measurement and DC Motor for spraying sanitizer. This system has been tested on various individuals.
22		2021	The author's provided module is an unique automatic hand sanitizer-cum-temperature detection system that can simultaneously sanitise and measure temperature without any interaction with the machine, eliminating the risk of infection from manual sanitizer dispenser usage. The main components used are PIR sensor, Ultrasonic(HC-SR04) sensor, Temperature sensor(MLX90614), Submersible pump and Arduino Uno R3. The system has been tested on TinkerCAD as well as implemented physically.
23		2021	The authors created a risk-free system that combines a Sanitizer Dispensing System (SDS), a Temperature Monitoring System (TMS), and a Pulse Rate and Oxygen Level Monitoring System (POMS) into one Hybrid System.. The main components used are MLX90614 temperature sensor, Obstacle Avoidance sensor, MAX30100 Pulse oximetry sensor, Arduino Uno and NodeMCU. Various additional add-on values are suggested to be implemented in the future scope section.
24		2021	The authors presented a contactless temperature measuring and attendance monitoring system that uses RFID to send data to a webpage to track details like entry time, ID number, number of students, and temperature measurements.
25		2021	The authors have proposed a system to assess whether an observed face is masked or not using CNN and OpenCV. They have constructed a real-time system that can capture the image of a person's face in a live video feed and assess it. The architecture used for CNN classification is VGG-16 (Visual Geometric Group). Webcam is used for obtaining picture data.
26		2021	Through the use of ordinary mobile devices, this work depicts a comfortable auto-monitoring system, specifically for senior persons. It uses a combination of signal processing and computer vision techniques to do contactless oxygen saturation measurements. Using short video frame sequence and ROI, Photoplethysmography is used on the face to detect the contractions in cardiovascular tissues and SPO2 is measured. This system is not very effective and time consuming. Approaches for a more effective and efficient system are being worked on.
27		2021	On reviewing the paper, it suggests a low-cost Internet of Things (IoT)

			compliance system that measures body temperature, and alerts attendees and management to violations. MLX90614 sensor is used for temperature measurement and NodeMCU is the microcontroller.
28		2021	The authors have proposed an IoT Temperature and Mask Scanner based Entry System. Features like human eyes, eyebrows, mouth, nose, nostrils and iris are used to detect faces and further upon detection a CCTV camera detects the mask using an AI network. Thermophile IR Temperature sensor is used for Temperature detection. The system glows Red Light and bars entry to persons upon violation of any conditions and also sends alert signals to authorities to take appropriate action.
29		2021	The approach executes Contactless temperature sensing and mask detection subsystems on Raspberry Pi. Viola-Jones algorithm and VGG-16 architecture is used for mask detection, MLX90614 sensor having infrared thermography is used for temperature sensing and PIR sensor for automatic hand sanitizing. LCD display is used to display messages and ESP8266 for sending alert signals along with buzzer for safety purposes. The accuracy of this system is 93.884%.

III. DISCUSSION

The study of this paper was to understand current technology used for protection against Covid19 by enhancing their techniques and designing a better version of the existing prototype. Firstly, the essential part of every system is detection of face masks with the help of a suitable architecture to minimize the time constraint for training and execution. Many papers proposed the use of MobileNet architecture as the finest network due to its advantage of less time taken to train and yields a good accuracy(0.439^{o}C Root-Mean-Squared Error compared with Standard Thermometer) with a minimum memory utilization(400Kb). There are some limitations with this network, for example, the accuracy of MobileNet can be compromised as per training parameters and there are multiple neural networks which provide a better validation output than the existing network. This work can be extended more by studying and comparing it with different architectures and trying to select a model which yields better performance.

Moving forward, another essential variable to prevent the spread of virus is to scan the temperature of an individual and verify whether he/she satisfies the given criteria. The given papers suggest the use of a temperature sensor named MLX90614 which is a contactless sensor and can be used in a proximity range to verify the results. This sensor gives a better accuracy($\pm$0.3^{o}C) when the individual is in an appropriate range.

In this study, there are some papers focusing on heart rate and oxygen levels to monitor the health of patients. The papers illustrate two different approaches to detect SpO2 levels. The first approach uses a digital camera to detect the motion and contraction of the muscles of an individual whereas another one uses a direct contact with the help of a RED and IR led. The former one is time consuming as it needs time to record the motion of an individual and provide an approximate result. Hence, the accuracy of this model is compromised. The latter one gives better accuracy as compared to the former one because it is faster and more invasive.

Succeeding to detection and scanning, an individual may be granted entry if all the parameters are satisfied. The entry systems usually are too expensive and can affect the cost of the whole design. To move to a cost effective design, the entry systems can be designed in a way that consumes less power and provides accurate results. Advancing with the entry systems, a paper implemented a QR code based authentication system to maintain the records to the visitors and store the data in the cloud for further use.

Multiple papers indicate the use of hand sanitizer systems with different techniques to prevent the spread of virus. These include a hand sanitizer dispenser, spray dispenser and spray using a nozzle machine. A major drawback of these systems is that they are costly and some of them suffer from wastage of sanitizer liquid. An effective system can be designed to minimize these effects which can give a better reliability.

All the papers focus on some or the other parameters and have designed a system according to it. These different systems can perform better, faster and can be more reliable by tuning some parameters. Furthermore, a sustainable system can be designed which includes all these parameters embedded in a single system giving better performances and saving more time for the prevention process.

IV. CONCLUSION

The techniques discussed above can prove to be extremely helpful in getting the pandemic under control and also raise chances of reducing any chance for uprising of future similar pandemic causing diseases. The techniques like Facial Mask Recognition, Temperature Measurement and SPO2 Measurement are being implemented and being developed to increase their efficiency, accuracy and reliability. Even though these devices are available individually, but no research or implementation has been done to integrate these devices into a single device which could increase reliability and also can be highly cost-effective. The main objective of this study was to provide a summarized analysis of various technologies which are necessary to implement a single device incorporating these technologies with reliable accuracy and effectiveness, and also to encourage other researchers to do research in this field so development can take place eventually helping the world to move towards a better future. Further work is to use the results of these papers and devise a system incorporating these technologies and implement a cost-effective system.

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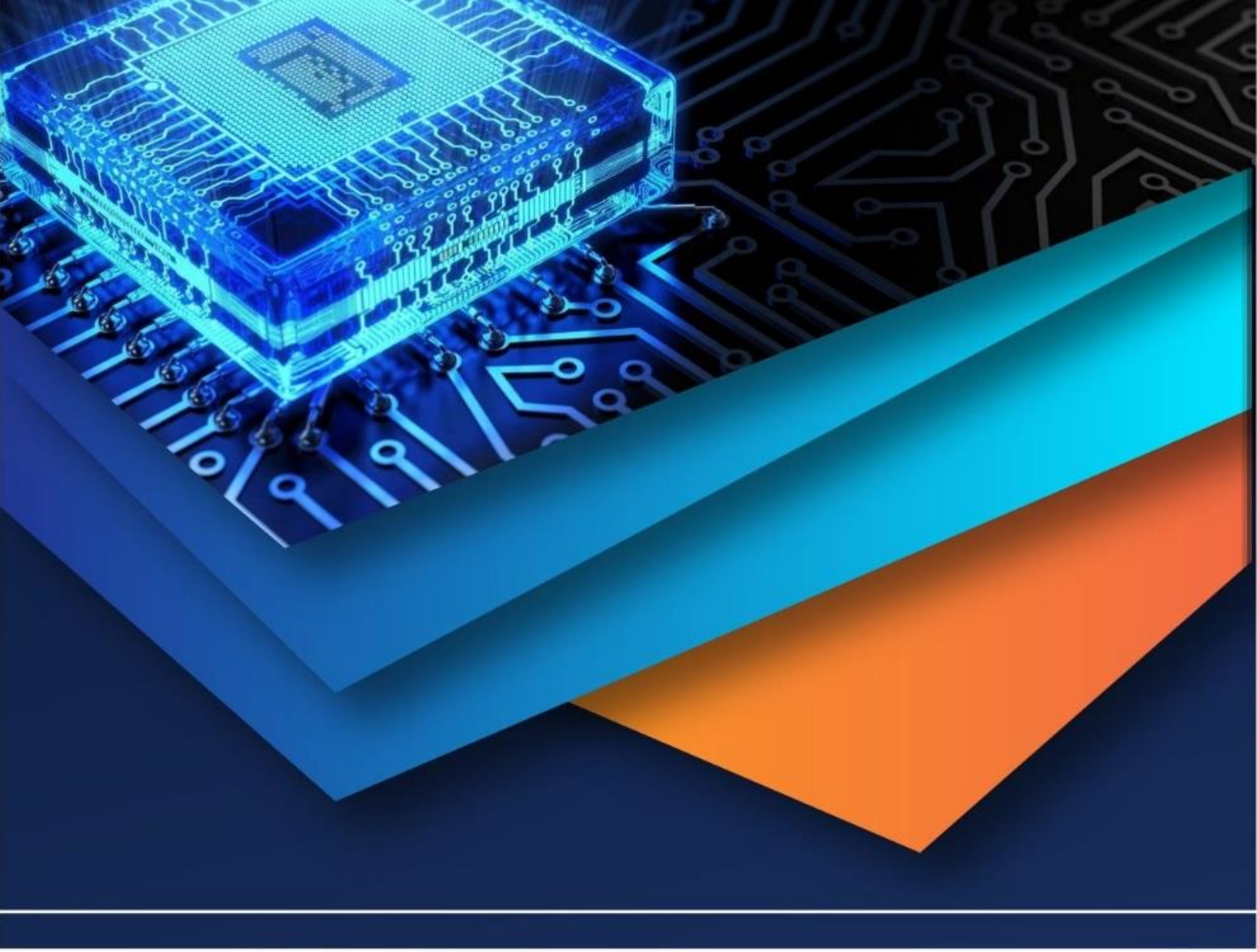

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