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Suraksha – A Public Safety System for Covid-19 using Raspberry Pi

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Abstract - This project involves the design and development of a Public Safety System for COVID-19 using Raspberry Pi. The main purpose of the work is to create a safe environment that contributes to public safety in these difficult times. It is an efficient approach focused on automated monitoring of people in public places to detect if they are wearing a mask. This device is the integration of multiple devices which together indicate if the detected person is wearing a face mask or not. The device consists of a Raspberry Pi, a Raspberry Pi Camera, RFID Scanner, LEDs, LCD Display and a Buzzer. The device can be used as an entry level system to perform authorization of entrants in real time. This proposed design will address in depth the identification of people wearing a mask that helps to ensure human health. The solution has the potential to drastically minimize violations by real-time interventions and improve public safety by saving time and helping to curb the spread of Covid-19.

Key Words: Image Processing, Haar Cascade, COVID-19, Raspberry Pi, OpenCV, Python

1.INTRODUCTION

COVID-19 disease is an infectious disease caused by the novel coronavirus referred to as SARS-CoV-2. Many patients experience mild to moderate respiratory illness as a result of the COVID-19 virus, including fever, cough, shortness of breath, breathing difficulties, fatigue, and sore throat and recuperate without any special treatment. Older persons and individuals with existing medical problems, on the other hand, may require hospitalization since they are more likely to acquire serious sickness. World Health Organization (WHO) reports suggest that the main reasons for the spread of COVID-19 virus are respiratory droplets and physical contact [1]. When an infected person coughs or sneezes, there is a high chance of a person within the range of 1 meter being exposed to infective respiratory droplets. Wearing a face mask is one of the best ways to limit the spread of certain viral diseases including COVID-19.

The COVID-19 pandemic has led to the tragic loss of human life worldwide and has presented a massive challenge to public health and the economy. The lockdowns which were imposed all over the world led to a standstill of normal life as we know it. The proposed design aims to provide a fast and reliable public safety system for the following purposes:

- To use the present technology to develop a device that contributes to public safety and curbs the spread of COVID-19.
- To monitor and identify whether the person is maintaining safety standards by wearing a mask.
- To provide authorized entry into the premises by means of RFID scanning and maintain the attendance in the form of a database.

2. LITERATURE SURVEY

As a part of the literature survey, various research papers and journals were referred to and the following observations were made:

- W. Zhao et al. present an extensive survey of machine recognition of human faces. They explain in detail about how image processing can be used to detect the face from any input image or video and how this information can be used for further operations. [2]
- Kruti Goyal, et al. discuss about the algorithms and methods of Face recognition using Open CV. [3]
- Faizan Ahmed, et al. provide various face detection and recognition methods with higher response rate and accuracy. [4]
- T.S. Gunawan et al. in discuss about a Face Recognition System designed using Raspberry Pi along with the camera module. [5]

The grave situation of Covid-19 has prompted many researchers to develop solutions to mitigate the issue. A few solutions developed in the field of mask detection are:

- M. M. Rahman et al. proposed a sophisticated automated framework for screening those who do not wear a face mask [6]. A CNN-based learning algorithm was used to recognise patterns in photos of people with and without masks collected from various sources. The proposed system detected face masks with an accuracy of 98.7%.
- S. A. Sanjaya et al. developed a face mask recognition method with MobileNetV2 in their study [7]. With a 96.85% accuracy, the created model was able to distinguish between those who were wearing a face mask and those who were not.
- P. Nagrath et al. employed deep learning, TensorFlow, Keras, and OpenCV to detect face masks [8]. The SSDMNV2 approach detects masks in real time by using the Single Shot Multibox Detector as a face detector and the MobilenetV2 architecture as a framework for the classifier. The accuracy score for the methodology used in this paper was 0.9264.
- B Batagelj et al. propose a complete pipeline for evaluating if masks are worn correctly in their paper [9]. The performance is compared with standard mask detection models. They gathered a large dataset of facial photos from the publicly accessible MAFA and Wider Face

datasets, annotating it with compliant and noncompliant labels to make the analysis easier.

3. BLOCK DIAGRAM AND WORKING PRINCIPLE

Figure 1 as shown below illustrates the block diagram of the proposed system:

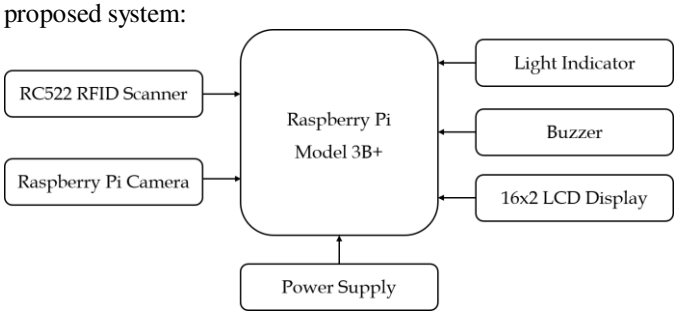


Figure 1: Block Diagram of the Proposed Design

The hardware implementation of the proposed design uses the Raspberry Pi as the main processing device. The Raspberry Pi camera is interfaced using CSI connector to obtain the video input. The RFID scanner is used in conjunction with the tags to provide allowed access to the premises. An RFID tag is made up of two parts: a microchip that stores and processes data and an antenna which is used to receive and send signals. Each tag has a unique number which will be used to identify the person. Based on the inputs obtained from the camera and the RFID Scanner, the Raspberry Pi decides if the visitor can be allowed inside. If the person has been detected as not wearing a mask, the red LED will glow and the buzzer will turn ON to alert the person to not enter the room. Otherwise, the green LED will glow and the LCD display indicates that the person can enter.

The proposed design uses the Haar Cascade Algorithm with OpenCV to perform face mask detection. The mechanism focuses on many smaller subregions of the obtained image in order to discover a face by looking for certain traits in each subregion on a grayscale image.

The algorithm has four main steps:

1. Selecting Haar-like features: There are three types of Haar features: edge features, line features, and four-sided features. Edge and line features detect edges and lines, respectively. Diagonal features are identified using four-sided characteristics. The feature value is estimated as the difference between the summation of pixels in the black area and the summation of pixels in the white area. We get a piece of valid information out of the image using the value.
2. Creating an integral image: It is a summed-area table that calculates the sum of pixel values in an image or rectangular part of an image. The value at each point is equal to the sum of all pixels above and to the left, including the target pixel.
3. Running AdaBoost training: It evaluates each Haar-like feature and the subregions of the image. Some subregions with a greater difference in the integral image will provide a strong response. This is classified as positive. This step identifies the important feature to perform face detection.
4. Creating classifier cascades: This process divides the face identification into multiple stages to speed up the process. Each stage looks for a specific feature to classify if the image contains the face. If all phases approve the image, it is finally classified as a human face and given to the user as a detection.

This is how the program performs detection of the face from the input image or video. In a similar manner, classifier objects can be used to detect if the person is wearing a mask. The classifier objects can be used to detect the face and the mouth region. When a person is wearing a mask, the object will not detect the mouth corners and the lips as they are covered by the mask. This is classified as a 'Yes' otherwise it is classified as a 'No'.

4. HARDWARE AND SOFTWARE TOOLS

The hardware that used for the implementation of the proposed design is as follows:

- Raspberry Pi 3B+: It is a microcomputer which acts as the main processing unit of the device and handles all the activities of the device (shown in Figure 2). It is provided with all of the capabilities of a standard computer. It consumes very less power - about 3 watts[10].

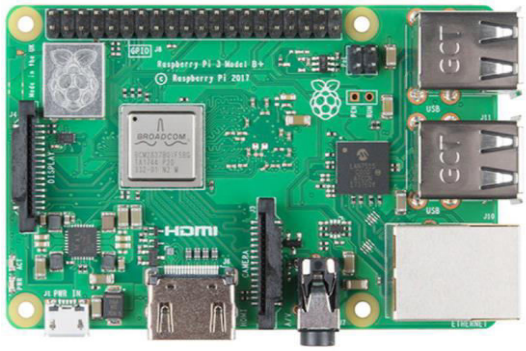


Figure 2: Raspberry Pi 3B+

- **Raspberry Pi Camera:** It connects to the Raspberry Pi and aids in capturing a person's face. It captures clear 5MP images or records 1080p HD video at 30 frames per second. It has a MIPI Camera serial interface with a 2592 * 1944 (resolution) Omnivision 5647 Digital Camera[11].
- **RFID Scanner:** It is used to scan the RFID tags in order to provide authorized entry. The RFID RC522 is a low cost RFID reader (Radio-frequency identification) which is based on the MFRC522 microcontroller reader and writer. It includes an RFID tag and a 1KB storage key tag [12]. It supports the I2C and UART protocols for communication. The operating voltage range is 2.5 to 3.3V.
- **LCD Display:** It indicates if the person can enter the room. A 16×2 LCD has 16 Columns and 2 Rows. It is interfaced with IC HD44780 which receives commands and data from the MCU, processes them, and displays data on the screen.
- **Buzzer:** It sounds on to alert the person if he/she is not wearing a mask. The piezo buzzer uses the reverse of the piezoelectric effect to produce a sound.

- **LED (Light Emitting Diode):** Two LEDs are used to indicate that if the person is wearing a mask or not.

The proposed design uses the following software tools:

- **Python:** The Raspberry Pi along with the interfaced components is programmed using Python. Python is dynamic, high level and an interpreted language used for programming which supports object-oriented and procedural programming paradigms. The Raspberry Pi which is primarily a Linux-based system supports Python of the box in the form of Interpreters like IDLE and Thonny IDE.
- **OpenCV:** The Mask Detection program is implemented using the OpenCV library provided by Python. OpenCV is a cross-platform library using which real-time computer vision applications are developed. OpenCV is available for Windows, Linux, Mac OS X, FreeBSD, and other operating systems.
- **Raspberry Pi OS:** The OS provides the GUI to perform the programming of the device. Previously known as Raspbian OS, it is a Debian-based operating system for Raspberry Pi.
- **MySQL:** MySQL is a database management system for relational databases (RDBMS). It maintains the database of the authorized users and their entry times into the premises.
- **Twilio SMS Messaging API:** The Twilio SMS Messaging API is used to send the SMS Alert to the recipient's mobile number. Twilio is a service that allows designers to make phone calls and send messages programmatically.
- **Apache Web Server:** It is used to create a dynamic front end webpage to display the databases. Released under the terms of Apache License 2.0, it is one of the commonly used free cross-platform web server software.
- **PHP:** It is a preprocessor code which works along with the Apache Web Server to display the MySQL database. It determines what information should be displayed on the website and transmits the same page to the browser. PHP, can display various material depending on the situation, i.e. it is dynamic.

5. ALGORITHM AND FLOWCHART

The algorithm for the hardware implementation illustrated in figure is as follows:
Step-1: START
Step-2: Obtain the input from the Raspberry Pi Camera.
Step-3: Identify if the person is wearing a mask. If yes, proceed to step 4. Otherwise, skip to step – 6. Step-4: Scan the RFID Tag on the RC522 Reader.
Step-5: If the user exists in the database, provide the entry into the premises and update the time of entry in database. Send an SMS to the visitor using Twilio API and turn on the Green Light.
Step-6: If the user is not wearing a mask, remind the person to wear a mask, sound ON the buzzer, turn ON red LED and do not provide entry into the premises.
Step-7: STOP

Figure 3 illustrates the workflow of the hardware implementation.

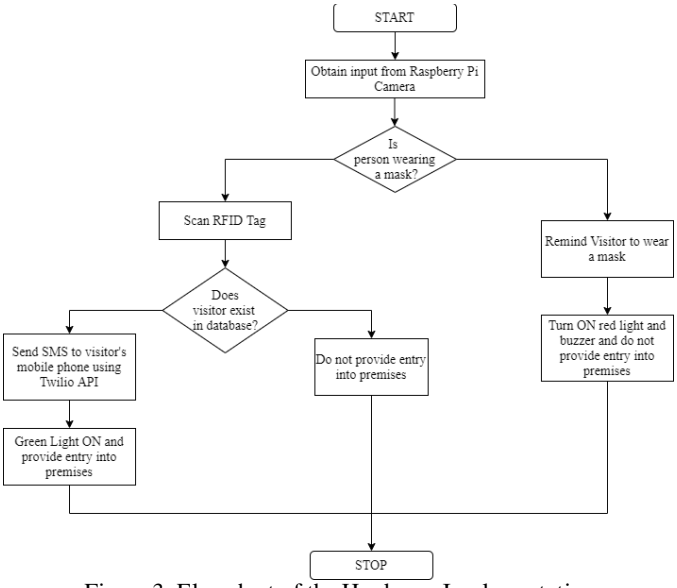


Figure 3: Flowchart of the Hardware Implementation

6. RESULTS AND DISCUSSIONS

The hardware components were interfaced with the Raspberry Pi to make a comprehensive entry system as shown in Figure 4 below.

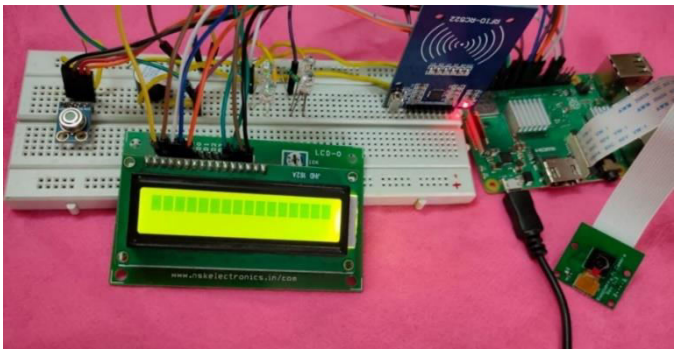


Figure 4: Hardware Setup of the System

The database of the authorized users is created using MySQL which stores the details of the user by scanning the RFID Tag. Figure 5 shows the LCD display which guides the user to save their details in the database. On running the program, the user scans their tag and the display asks the user to enter their name in the terminal as shown in Figure 5(a). The user enters their name and the database saves their name and tag ID as shown in Figure 5(b).

Figure 5(a): Entering the name of the user

Figure 5(b): User saved in the Database

The program for the implementation was executed on the Thonny Python IDE available on the Raspberry Pi and the results for the same were obtained as follows.

- If the visitor is wearing a mask, the program displays the output with the video input and a surrounding box which indicates "Thank you for wearing MASK" concluding that the person is safely protected. This helps the person from getting infected from the virus and preventing its spread. The result displayed is as shown in Figure 6:

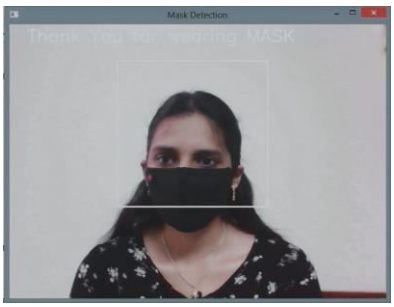


Figure 6: Visitor wearing a mask

The LCD display shows the result and the green LED is switched ON as shown in Figure 7 below:

Figure 7: LCD Display and LED Output for wearing a mask

The user then proceeds to scan the RFID Tag on the reader to record the attendance and the corresponding output is as shown in Figure 8:

Figure 8: Visitor is authorized for entry

An SMS message is sent to the visitor's mobile phone using the Twilio API as shown below in Figure 9:

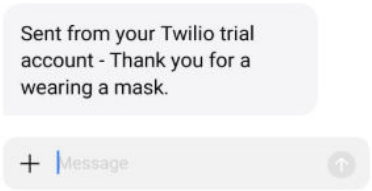


Figure 9: SMS received on the mobile phone (Mask Worn)

The database is updated with the entry time of the user as shown in Figure 10:

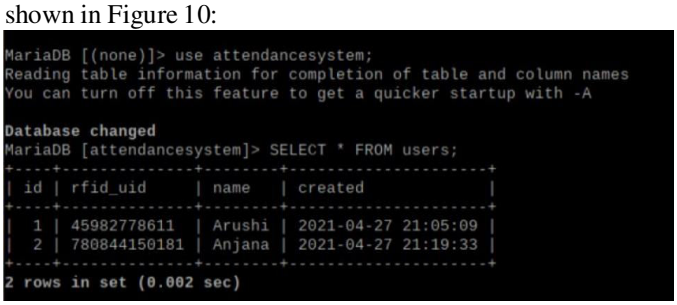


Figure 10: Database for Visitor Entry

The database of the existing users and the attendance log can be viewed in the Front End webpage created using the Apache Web Server and PHP. Figure 11 shows the Home Page of the system:

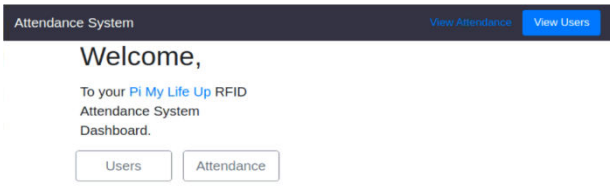


Figure 11: Home Page of the Web Front End

The user can select either the 'Users' or the 'Attendance' Button to view the database as shown in Figure 12. The 'Users' Database displays the list of authorized users who can enter the premises. The 'Attendance' Database displays the entry time stamp of the user against the User's name.

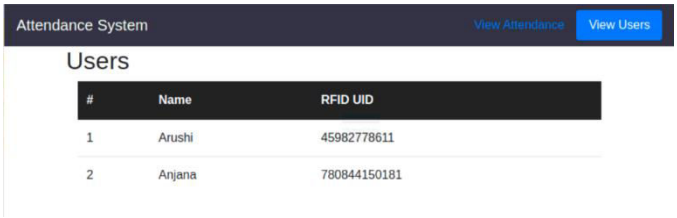


Figure 12(a): Users Database

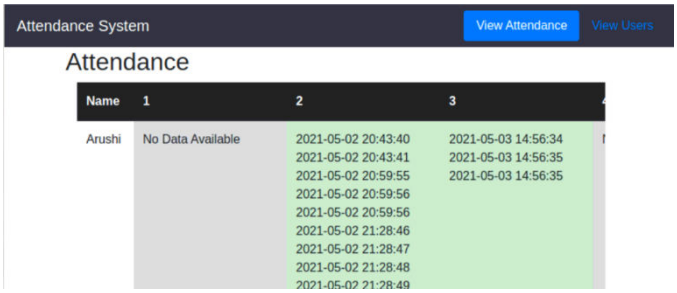


Figure 12(b): Attendance Database

- If a person is not wearing a mask, the program displays the output with the video input and a surrounding box which indicates "Please wear the MASK" concluding that the person is not protected and reminds the person to wear a mask in order to enter the premises which helps in stopping the spread of the virus. The result is as shown in Figure 13.

Figure 13: Visitor is reminded to wear a mask

The LCD display shows the result, the red LED is switched ON and the buzzer is turned ON as shown in Figure 14:

Figure 14: LCD Display and LED Output for not wearing a mask

An SMS message is sent to the visitor's mobile phone using the Twilio API as shown in Figure 15:

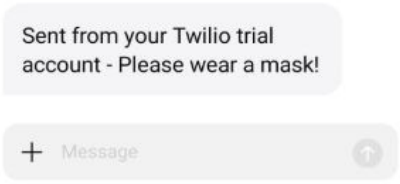


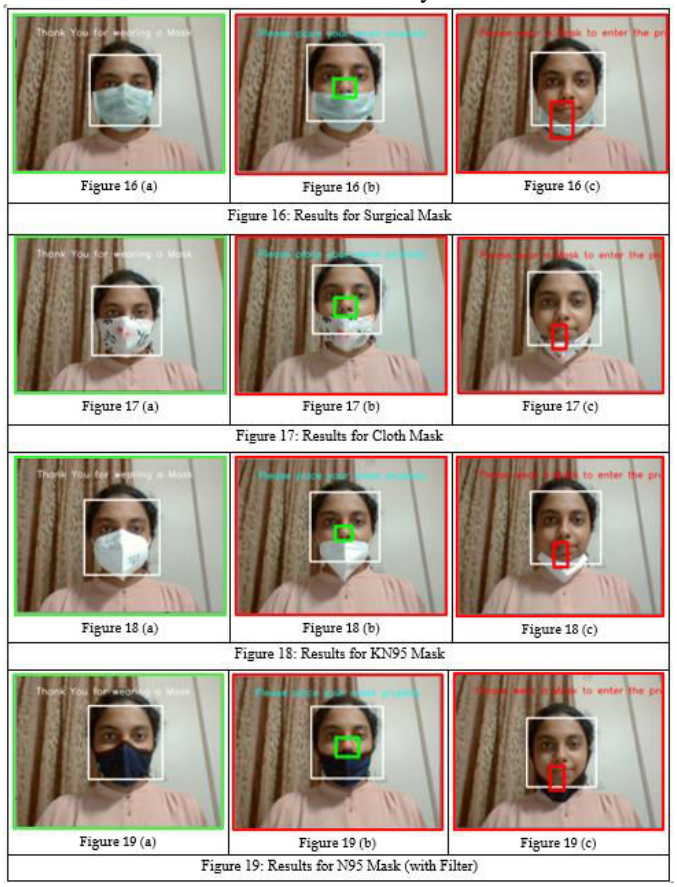
Figure 15: SMS Received on the mobile phone (Mask Not Worn)

Face Masks are a simple but critical tactic to slow down the spread of the Coronavirus. People wear many different types of face coverings, including bandanas, hand-sewn masks, and disposable medical masks [13]. Various types of masks have been tested for their efficacy against the transmission of Covid-19. N95 provide a protective advantage over surgical masks in laboratory settings, but even cloth facial coverings over the nose and mouth reduce the spread of the virus SARS-CoV-2 to some extent by filtration [14]. The device was tested for various types of masks of different colors – each for 3 different cases:

1. Mask worn properly (covering the nose and mouth)
2. Mask in incorrect position (not covering the nose)
3. Mask not worn properly (neither covering the nose nor the mouth)

The program uses the Haar Cascade Image Processing algorithm to differentiate between the three cases. It can also identify if the mask is worn incorrectly below the nose using the nose object. Although the algorithm is working efficiently, the performance could be enhanced in order to identify masks which are not effective such as bandannas or handkerchiefs by means of more advanced algorithms.

Table-1: Results of the program for different types of mask to test the efficiency



7. APPLICATIONS, ADVANTAGES AND LIMITATIONS

This device plays a crucial role towards ensuring protection from Covid-19 in the fastest way possible automatically. It aims to address the prevalent Covid-19 situation by providing a device for the benefit of the society.

The applications of the proposed design are:

- It can be used in public places like offices, colleges, malls, etc., to monitor visitors before they enter.
- It performs automated visitor authorization and maintains the log of visitors.
- It sends an SMS to the visitor easily by means of an API.

There are various advantages of the proposed design:

- It minimizes human-to-human interaction as the monitoring is automated.
- It provides a quick & contactless response.
- It is comparatively cheap.

However, there are also certain limitations which can be addressed with further improvements:

- It is an entry level system and does not perform continuous monitoring inside the premises.
- It performs the operation for a single visitor at a time.

8. CONCLUSIONS

We have proposed a Public Safety System with a face mask detector which can possibly contribute to public healthcare in these trying times. We may need to provide new versions as technology improves or as new customer requirements emerge to improve the functionality of the product. Despite the fact that the system is complete and functional, new modules that increase the system's functionality can be introduced without causing major system changes such as recognizing multiple masked faces, implementing temperature detection to detect symptomatic people and also providing sanitization facility at the entrance etc.

Modern technology will make the system more durable and reliable as the new modules include functionality that improves security. As a result, it contributes to the project's goal. The system can perform the real time monitoring of the visitors with a good accuracy. This proposed design will address in depth the identification of masks worn by people that helps to ensure human health. The proposed design has the potential to significantly minimise violations by real-time interventions and improve public safety by saving time and limiting the spread of Covid-19.

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