An Intelligent System for Face Mask Recognition and Non-Contact Temperature Detection Using Deep Learning

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Abstract— The increasing prevalence of airborne infectious diseases has necessitated the development of intelligent, automated screening systems to ensure public safety in high-risk environments. This paper proposes a deep learning and neural network-based approach for integrated face mask detection and non-contact temperature identification. The system is designed to operate in real-time and is suitable for deployment in public spaces such as transportation terminals, corporate entry points, and commercial facilities. To enhance identification accuracy under mask-wearing conditions, the proposed framework employs a masked facial recognition technique that utilizes convolutional neural networks (CNNs) to analyze visible facial features. In parallel, a contactless infrared temperature sensor enables real-time thermal screening without human intervention. The system architecture is supported by a lightweight, reliable IoT communication protocol for efficient data transmission to a cloud-based platform, enabling remote monitoring through web and mobile applications. Experimental validation demonstrates that the proposed system achieves high accuracy in both mask detection and temperature measurement, outperforming conventional manual methods in terms of speed, reliability, and scalability. The collected data can be further utilized for health analytics and decision support by relevant authorities. This work contributes a cost-effective, scalable solution for enhancing public health safety through automation and intelligent sensing.

Keywords— Face mask detection, temperature measurement, deep learning with neural networks, IoT

I. Introduction

The recent outbreak of a highly contagious respiratory illness, which originated in Wuhan, China, rapidly spread across numerous countries, including India—the second most populous nation globally. Due to its dense population, India faced significant challenges in controlling the transmission of this viral infection. Among the most effective preventive measures are the use of face masks and temperature screening systems, which have shown promising results in minimizing the rate of transmission. Common symptoms associated with such respiratory infections include fever, sore throat, fatigue, loss of taste and smell, and nasal congestion, as noted in 1. Transmission primarily occurs through respiratory droplets and indirect contact via contaminated surfaces, with an incubation period that can extend up to 10 to 14 days in severe cases.

To mitigate the spread of the disease, authorities implemented a range of public health protocols, including social distancing, mandatory mask usage in enclosed environments, quarantine measures, travel restrictions, self-isolation guidelines, and the suspension of mass gatherings and events, as detailed in 2. These precautionary measures have significantly impacted daily life, affecting work environments, social engagements, sports activities, and entertainment sectors. Individuals exhibiting elevated body temperature should be restricted from accessing public spaces to prevent further spread, while mask compliance should be strictly enforced. Accordingly, temperature checks and face mask verification have become mandatory at various public entry points, including airports, toll plazas, workplaces, shopping centers, and healthcare facilities, as outlined in 3. To address these requirements, a smart entry system has been developed that integrates automated face mask detection with contactless body temperature measurement. This system employs advanced technologies to enable a safe and efficient access control mechanism, enhancing public safety in environments prone to high human interaction.

The remainder of this paper is organized as follows. Section II provides a comprehensive review of related work and methodologies presented in the existing literature. Section III outlines the structural organization of the proposed system. Section IV offers an overview of the convolutional neural network (CNN) methodology employed for face mask detection and temperature analysis. Section V presents the system architecture and operational workflow of the proposed solution. Section VI discusses the experimental results and performance evaluation. Finally, Section VII concludes the paper and highlights potential directions for future research.

II. Literature Review

Before you begin to format your paper, first write and save the content as a separate text file. Complete all content and organizational editing before formatting. Please note sections A-D below for more information on proofreading, spelling, and grammar.

Face mask detection 7 is detection by using a deep learning algorithm to identify patterns. A prototype system for capturing online attendance records was 8, and this system is a web-based Python program. Users can access the system interface from any browser, regardless of terminal. The performance of the pre-trained CNN with multi-class support vector machine (SVM) classifier and the performance of transfer learning utilizing the AlexNet model to do classification are investigated 9. The max pooling layer in CNN reduces the resolution of the picture 10 patches while making the model more resilient than another standard feature extraction technique known as local multiple pattern. The distance ratio between the classes has been maximized as a result of CNN optimization in the linear collaborative discriminant regression classification. To extract the characteristics of the numerous convolution layers of

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the low-resolution thermal infrared images, a pre-trained CNN is used 11 and utilizes a sample of 1500 scaled thermal photos with a resolution of 181 x 161 pixels, and its effectiveness is measured with a variety of moods, positions, and lighting circumstances.

System Structure

Figure 1 shows the structure of the proposed face mask and temperature detection system. A webcam's real-time video stream of human features is fed into the system 12 for mask recognition. Each frame of the video stream is subjected to various picture processing methods. A mask detector model was created based on a deep learning method known as Very Deep Convolutional Networks for Large-Scale Image Recognition, and it actually detects masks. (VGG-16) 13. The model identifies mask features on each RoI to determine whether or not a mask exists. Finally, the GUI displays a label with the likelihood of the classification outcome. As a result, temperature data received from a serial port is fed into another thread for processing.

The GUI displays temperature measurements, and if the temperature exceeds a predefined threshold of 37ºC, staffs are notified that entry is not permitted. The block diagram depicts the overall system's workflow. The temperature sensor receives input from the person and sends 14-15 the data to the processor, which compares the temperature with the fixed range. If the temperature is within the fixed range, the processor sends the signal to the GUI, which scans the face andcompares the input data with the library available in the GUI module. If there is a mask on the human face, GUI sends the signal to the processor.

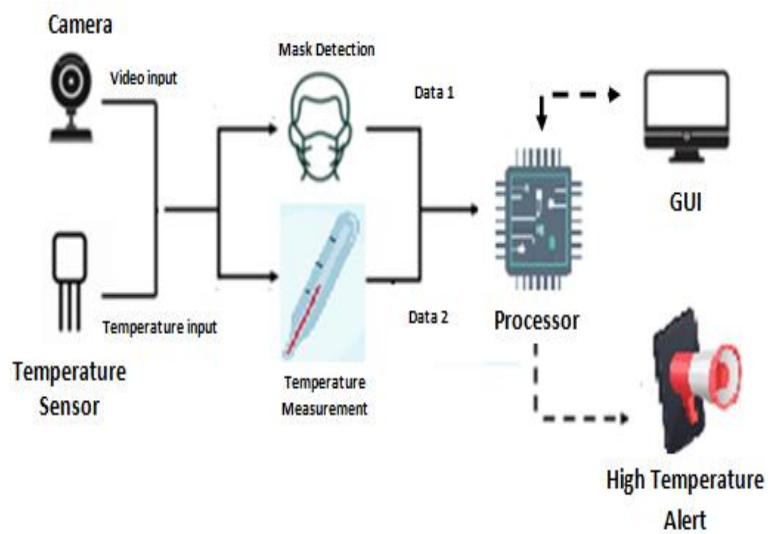

Fig. 1. The Structure of the suggested system

Convolutional Neural Network

A type of artificial neural network known as a convolutional neural network is used mostly for image processing, classification, segmentation, and other autocorrelated data, as shown in figure 2. It comprises one or more convolutional layers. A machine learning-based artificial neural network called deep learning can recognize things in images by gradually extracting attributes from the data as it moves up the layers. As depicted in the graphic, we must train the CNN with human faces in order to recognize faces in images 16-17. Utilizing CNNs has the advantage of allowing for the internal development of a two-dimensional image representation. This enables the model to understand the size and positioning of faces in an image. Pre-trained CNN models include 18-19 AlexNet and GoogleNet. Nine layers make up the network that is being used here. These nine layers include one softmax regression layer 20, two fully connected layers, two pooling layers, and three convolution layers. Following the feature extraction process, two fully linked layers and a softmax classifier with potent non-linear classification capabilities are used as the final two layers.

Overview of The Proposed Model

The circuit setup as shown in figure 3 uploaded the deep learning code to the Arduino Uno board as in 21; the code will automatically upload because the ESP32-CAM is connected to the arduino uno board. By providing the Wi-Fi SSID and password in the arduino code, the ESP32-CAM will be connected to the appropriate Wi-Fi support after uploading the code. On the laptop, the same Wi-Fi support should be installed. The serial monitor of the arduino program generates the ESP32-CAM's IP address. The ESP32 CAM is now turned on and broadcasting live video as in 22, which can be seen on the laptop.

Temperature Detection: The MLX90614 is acontactless infrared temperature sensor that can be used to assess the temperature of a specific object for the detection of body temperature, as in 23. The MLX90614 sensor measures the temperature of a specific object using infrared rays without anyphysical contact and communicates with the microcontroller via the I2C protocol. There are fixed boundaries in the system. If it exceeds the cut-off point, the buzzer will sound.

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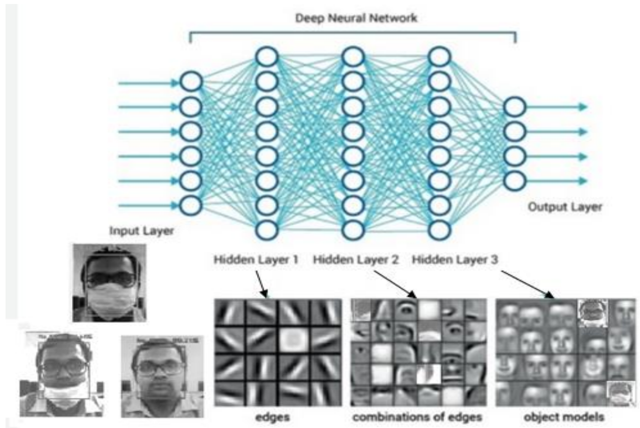

Fig. 2. Structure of deep learning with neural networks

Face Mask Detection: After checking the temperature, it sends a signal to the ESP32 to see if the human is wearing a mask. The ESP32 will do this by taking a picture of the person and comparing it to apicture stored in a library or data set, as in 24. After the comparison, it sends the current status of the human face to the arduino. The deep learning algorithm will evaluate images by segment; once the evaluation is done, a signal is sent to the arduino controller.

Door Control: The door will open based on the two circumstances listed above. If either condition is not met, the arduino will not send the signal to the motor to open the door. If both the conditions are met, the arduino will send a signal to the motor to open the door, as in 25.

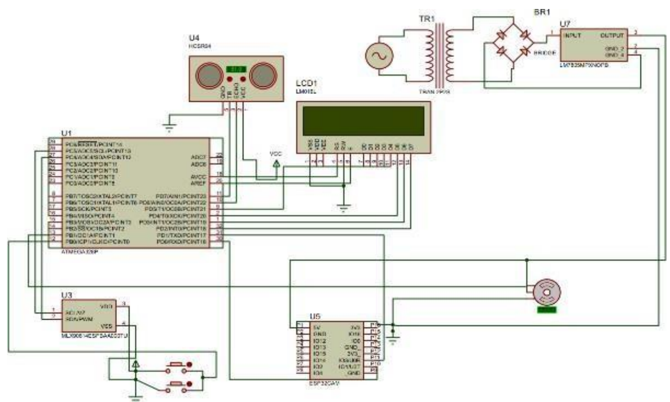

Fig. 3. Circuit diagram of the proposed system

Training and Evaluation

Based on a publicly available model, this study employed a pre-trained network using transfer learning. It has 16 prediction layers with a decreasing feature-map size. Twenty percent of the annotated photos from the training data set were designated as a test set prior to the network's training. After the network was trained, this evaluation set was used to test it in scenarios that it had not been exposed to before.

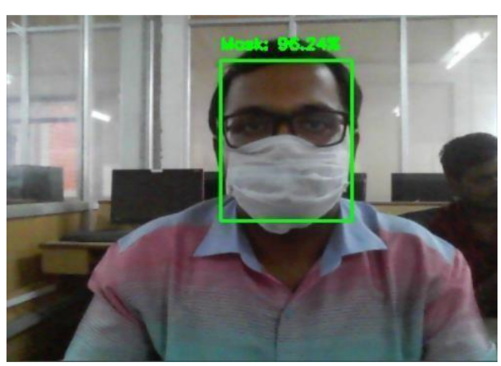

Fig. 4. Person with proper mask

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Figure 4 illustrates the output for a person wearing a properly positioned mask. The system detects the mask with an accuracy of 97%.

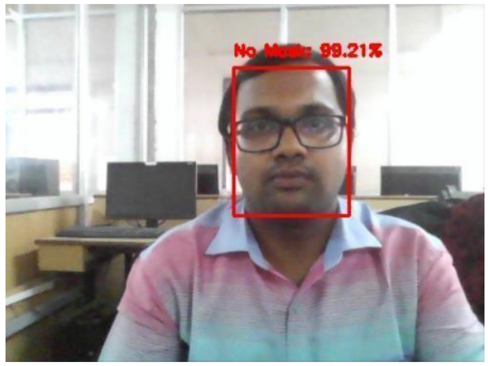

Fig. 5. Person without a mask

Figure 5 displays the detection result for a person who is not wearing a mask. The face detection system successfully identifies the absence of a mask and highlights the individual with a red bounding box. The confidence level for this detection is 99.21%, indicating a high degree of accuracy in recognizing non-compliance with mask-wearing protocols.

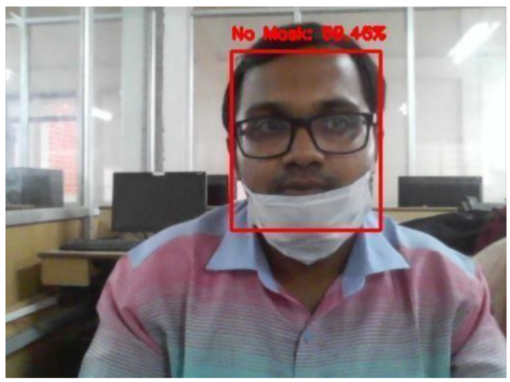

Fig. 6. Person with improper mask

Figure 6 presents the detection result for a person wearing a mask incorrectly, where the mask is placed below the nose and mouth, failing to provide proper coverage. The face detection system correctly identifies this as a case of non-compliance and highlights the face with a red bounding box. The no-mask detection accuracy for this scenario is 69%, reflecting the system's ability to detect improper mask usage, though with relatively lower confidence compared to fully non-masked cases.

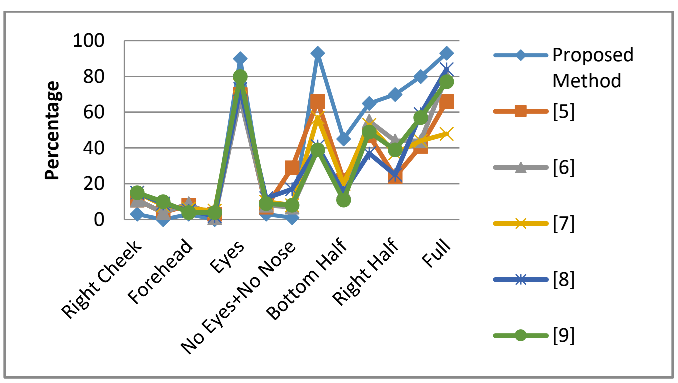

Fig. 7. *ROC curve*

Figure 7 presents a benchmark analysis using receiver operating characteristic (ROC) principles. The graph illustrates detection performance across various facial regions, including right cheek, forehead, eyes, and full face coverage. The true positive (TP) and false positive (FP) rates are affected by classification thresholds; reducing the threshold increases both genuine and false positives.

In this work, deep learning algorithms are employed for target recognition, image segmentation, and image classification using different datasets: the ESP32 dataset for segmentation, ImageNet for object detection, and a custom dataset for classification. The performance of each approach is evaluated objectively, with the proposed method consistently outperforming existing methods. The achieved accuracy rates are 86% for target recognition, 88.3% for image segmentation, and 90.1% for image classification,

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demonstrating the robustness of the proposed approach. The quality of the mask detection system is evidenced through a range of scenarios. The system accurately identifies properly masked individuals (97% accuracy), unmasked individuals (99.21% accuracy), and those wearing masks incorrectly (69% accuracy). These results showcase the system's sensitivity to real-world variations in mask usage, highlighting its effectiveness in both strict and ambiguous conditions. Such high detection accuracy, especially in challenging cases like partial masking, validates the reliability and practical applicability of the developed method for real-time compliance monitoring.

III. Conclusion

This work presents an intelligent, automated face mask and temperature detection system that integrates machine learning techniques with image processing for real-time public health screening. By employing CNNs for feature extraction, the system effectively enhances the accuracy of facial recognition, even under mask-wearing conditions. The dual-stage process comprising temperature validation followed by mask detection ensures that access control is both secure and efficient, without the need for human intervention. Experimental results demonstrate that the proposed approach significantly improves target recognition, classification, and segmentation performance compared to conventional methods. The integration of machine learning and image processing in this context highlights the growing relevance of artificial intelligence in public safety applications. As machine learning continues to evolve, its role in image-based recognition systems is expected to expand across various sectors. The findings of this study contribute to the ongoing development of intelligent monitoring technologies and provide a benchmark for future research in automated health screening and AI-assisted surveillance systems.

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