Automated Face Mask and Contactless Temperature Verification using CNN and DHT11

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One has to wear a mask properly, be checked for normal temperature, and be sanitized before entering the building. Currently, the watchman of the building or certain people specially hired for the role, are performing the above tasks manually. Although the manual process has its benefits, this is quite a time taking process and also has the danger of exposing the person at the checking booth to the corona-affected patients directly. Keeping the gigantically pervasive corona pandemic in mind, if the above process goes automatic, it could reduce the manpower, eliminate the danger of contact with corona patients, use time efficiently, and would be cost-effective. It is a fact that face mask recognition systems already exist, but a complete system for all the above-mentioned tasks does not exist at the moment. Our idea is to propose a system called "Automated Face Mask Verification and Temperature Verification using Convolutional Neural Networks (CNN) and DHT11" which includes all the above functionalities that would be done automatically without the physical presence of anyone. To achieve the major objective called accuracy in Face Mask Verification, CNN models are chosen as model training algorithms. This system also explores how to achieve contactless temperature verification reliably using the most popular cost-efficient, contact sensor called DHT11 with a comparative analysis on the existing contactless temperature measurement techniques.

Keywords: Corona Pandemic, Face Mask Verification, Contactless Temperature Verification, DHT11, CNN, Cost-efficient.

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1 Introduction

The COVID-19 pandemic has reshaped life in ways that we cannot imagine. People are constrained to stay at home and change their daily habits, like going to school or work to stay safe. It is important to adopt new routines while changing our old habits. The most important habit that is to be adopted is the habit of wearing a mask or covering the face whenever we are outside the house. Adding to that, the habit of wearing a mask or face covering whenever we go out and situations have arisen that mask has become necessary even at home. So wearing a mask and verifying whether a person is wearing a mask or not have become an inevitable part of the gateway verification process of every public place.

At present, the above-mentioned steps of verification are done manually by either the watchmen or a specially appointed team of people for verification. But this manual process has a huge con that the watchmen could be exposed to the corona-affected people which might result in the watchmen being affected with coronavirus. A local study on the age group of watchmen showed that most citizens of age greater than 45 join as watchmen. This implies that the potential threat of coronavirus on the life of watchmen is humongous as corona affected old age people who are more prone to death. So this system of verification manually is not helping in reducing the spread of coronavirus effectively.

We propose a new system, Covid19 Gateway kit which uses face recognition to know if the person is wearing a mask or not and there is contactless temperature detection, and finally, there is a module for automatic sanitizer sprayer. The main aim is to integrate these two and implement them as a whole kit. In this project, we are integrating face recognition and temperature detection modules. During this pandemic, the cheap and most effective way to decrease the spread of the virus is to wear a face mask as there is no vaccine or medicine available that kills the virus. Masking up is an effective way that limits the transmission of the disease along with washing hands and maintaining a physical distance. The virus spreads from person to person through direct contact or in the form of respiratory droplets when an infected person coughs or sneezes. The droplets may affect others when they accidentally inhale those droplets or they land in the mouth or noses of people.

As the coronavirus is contagious, one should be cautious in public. The virus spreads easily when one coughs or sneezes. The face mask acts as a barrier reducing the spread of the virus. The mask may not give complete protection but helps us to control the spread of the virus. One should wear a mask not only to protect themselves but also others. Even though the person who is affected with the covid-19 virus may not show any symptoms at first but he is capable of spreading the virus. So, everyone should wear a face mask.

Many studies have shown that face coverings can contain droplets expelled from the wearer, which are responsible for the majority of transmission of the virus. Experts say that the spread of coronavirus when all wear masks would be 1.5% which could save the lives of many people. Due to this fact, only people wearing masks are allowed outdoors or in public organizations. It is essential to understand the importance of face masks in this type of pandemic. The face mask module consists of a camera to identify whether a person has a mask on or not. In this kind of situation, there is a check at entry points in malls or institutions almost everywhere. To reduce manpower and to save the person from direct contact while checking temperature and sanitizing the person. When the face mask is identified it is indicated by a green square box displaying "Mask". The red color box indicates that the person has no mask which displays "No mask".

Along with mask verification, coronavirus-affected patients are strictly prohibited to enter any public place and are directed to be quarantined. This helps reduce the spread of coronavirus as there would be no carrier of the virus. To prevent the patients from entering public places, a step of verification is added at every public entrance, verification of temperature. Fever is one of the symptoms of coronavirus, so at every public entrance, the temperature of the person entering the building is checked to see if it is normal or not. If it is normal, then the person is allowed to enter otherwise, he is not allowed.

At present, everywhere people are following the traditional method of checking temperature, which has a security or staff member standing at the entrance with a temperature checking device in hand and pointing it to their forehead at a distance of one or two-inch gap or to their hand. After checking the temperature, if it is acceptable they are allowing the people or if it's beyond the acceptable range they are restricting the person from entering. It is being followed everywhere, at every shop or supermarket, or mall. Staffs at every place are appointed to check the temperature. Assuming if a Staff member appointed to check the temperature at one shop checks nearly ten and hundreds of persons then what about a market and a mall? There are hundreds of people going there. To check them, there is a lot of effort that needs to be taken by staff members to protect themselves from the virus.

Even after taking measures, they are getting affected one or the other way. Maybe the person who is entering was affected and somehow because of his less protected mask the respiratory droplets may pass to the staff member’s hand and the same person checks temperature for others too. There are many possible events of getting affected. To protect the staff members who are checking temperatures and getting affected, we are working to replace them with a machine where there is contactless temperature detection and the possibility of people getting affected is also less.

It is as simple as placing a hand near the machine that has instructions too to guide the people. There is no need to touch the machine. We can simply place the hand a bit away from the sensor. As our hand moves towards the machine, the motion sensor recognizes the movement and after letting our hand near the sensor the temperature is measured and displays whether it is accepted or not. Finally, it decides whether the person can enter or not. This process helps the staff members to do their work from a closed cabin and make sure that the people that enter the mall after all checking are done. And if anything went wrong and if they try to enter then the same temperature values are also visible to the staffs that are inside and they can take a certain action by restricting them to enter. After completing the mask and temperature check they can apply the sanitizer present at the entrance and enter without any chaos.

To build a reliable system the existing techniques, sensors usage, and approaches are studied in detail and they are cited as well to indicate their influence in reaching our system. A total of 8 papers are discussed in the literature survey section.

2 Literature Survey

Liao et al [1] proposed a system to detect faces by overcoming the problems that arise with unconstrained face detection. The problems with unconstrained face detection are occlusion, pose variation, and speed of face detection. In this paper, authors proposed a new feature called Normal Pixel Difference (NPD). NPD is to extract the pixel differences and group the pixels to obtain the face locations. A deep quadratic tree is used to train the model to identify face segments and detect the face. The model is reportedly six times faster when compared to the one with the OpenCV library in python. This model has been tested with popular face detection datasets like FDDB, GENKI, CMU- MIT which shows that the model is a state-of-the-art kind of model.

Gao et al [2] propose a method of estimating the 3D head pose using a convolutional neural network with Siamese structure. Firstly, the rank labels of head pose which is used to train the Siamese network can be automatically generated from the continuous head pose labels. The Siamese network can rank the head pose deflect levels and this step is equivalent to coarse classification. Secondly, after the Siamese network is trained, the continuous raw pose labels were used to fine-tune a branch of the Siamese network and let the network regress the continuous pose ground truth. To avoid duplicate computation caused by the Siamese network, add an ensemble layer to the network. In addition, high-intensity brightness adjustment and Gaussian blur are imposed on images to distort images in data augmentation, so our method will achieve perfect performances in low-quality images. Experiments show that the method has higher accuracy than the state-of-the-art methods of estimating head pose from RGB images, stronger robustness than the method of head pose estimation with key points, and wider application range than the method of head pose estimation with depth data.

Moisello [3] proposes a sensor and its circuit which is suitable for contactless temperature measurements. The sensor is made of a miniaturized micromachined silicon thermopile which has 180-V/W responsivity, 540-kΩ output resistance, and 0.64-mm 2 active absorbing areas. The interface circuit uses the chopper technique to amplify the output signal of the sensor, which acts as a DC while reducing offset and noise contributions at low frequency. Based on the sensor characteristics, a single-ended architecture was preferred over the most straightforward fully-differential approach. The interface circuit reduces the offset by a factor of 255, achieving an input-referred offset standard deviation equal to 1.365 μV, measured across 29 samples. The thermopile sensor and the interface circuit are standalone devices and together as a system perform contactless temperature measurements. To reduce the environmental noise a metal cap is added to the thermopile sensor. The measurement accuracy obtained was ±0.2 °C approximately. This proves that the system is suitable for the detection of human body temperature.

Hung [4] proposed a focusing reflect array that focuses on a particular point. It is mainly designed to use as a part of the microwave virus sanitizer. There are traditional far antennas; the difference between both of them is that the traditional antennas form a planar phase in a specified direction whereas the focusing reflects array focuses at the predetermined focal point. A prototype antenna is created and it was used for sanitization of the H3N2 virus. To kill a virus using this method MRA (Microwave absorption) frequency of the virus is to be calculated. Then sufficient power density required to inactivate the virus is provided at the focal point.

Chun [5] proposed common occlusion and pose variations for face detection. For experimental data and evaluation criteria, over 9000 face images were obtained by rotation, scaling, and translation, from the 4000 images were used for training and 5000 images used for testing. In addition, all the images were cropped and resized. For experiments on occlusion, they selected a few images which contain faces with occlusion. Some of them are correctly detected and some are not. The author divided the face into several parts from forehead to chin. Firstly, the face has been divided into regions from which features are extracted from the face. It is done by establishing gray distributions. Using classifiers, each region is identified and assigned with random fields are established based on the labels and multiple dependencies between the parts were modeled in a framework called CRF Framework. These experiments are being carried out on the Carnegie Mellon University (CMU)/Massachusetts Institute of Technology (MIT) testing set introduced by Rowley. This approach achieved a higher rate of detection and a lower rate of false detection.

Tang et al [6] proposed a system, as many people have a fever while being infected by communicable d body temperature monitoring is important to prevent such diseases. Because of the outbreak of influenza in Hong Kong, some schools are taking measures and are measuring the student's forehead temperature when they arrive at the school. Taking attendance and temperature logging consumes more manpower, time, and administrative resources as it is a repetitive task. To facilitate such daily operations at the entrance of the school, an automatic system with multiple functionalities such as attend taking and temperature measurement is being developed in collaboration with an access control company present in Hong Kong. This paper presents a prototype system, which contains a non-contact temperature sensor, an embedded system, and a database. When high temperatures are detected it automatically informs the management department and displays the values. These records are stored and are made available. Using a special mechanical fixture and simple calibration technique, preliminary results have shown desirable temperature measurement performance.

Khan [7] briefly reviews various methods of sanitization for individuals, surfaces, and ambiance. The article reviews different approaches toward sanitization and examines the historicity of the methods employed. Sanitization for surfaces and ambiance can tackle the spread of the COVID-19 virus in professional and domestic spaces. Chemical disinfectants applied to floors, doorknobs, table surfaces and surfaces in domestic and office use can be used to deactivate the corona spread.

Song [8] discussed various available Continuous Body Temperature Measurement (CBTM) techniques in his study. To not disturb users' daily activities, CBTM devices are mostly noninvasive and wearable. As the activities performed by the wearer can bring changes to the temperature measurement, the CBTM devices take a long time to give the final output. C. Song has differentiated between Wearable and non Wearable CBTM devices and also discussed the influence of the effect of the device temperature on the output measurement. He proposed a multiple Artificial Neural Networks (ANN) based CBTM method which is reported to have a reaction time of one-tenth of popular devices available in the market.

3 Proposed System

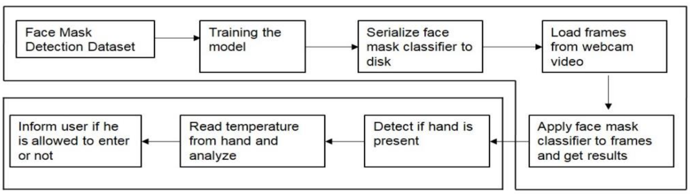

Fig. 1 Proposed System

Our proposed system consists of the following steps:

1. Face Mask Verification
2. Temperature Verification

So to attain the two steps, each module is assigned to perform each step mentioned above.

3.1 Face Mask Dataset: The Face Mask Verification module needs a dataset in order to train the classification model and predict whether the face mask has been detected for the person to pass through the gate or not. The dataset containing 7553 was extracted from Kaggle resource [1 without a face mask. The dataset contains 2 folders named with_mask and without_mask which contains 3725 and 3828 images each respectively.

3.2 Data Preprocessing: To work with a large dataset and to produce better results, the dataset images have to be preprocessed. The preprocessing used here is to resize each image to the same size and avoid any noise within the images. Blurred images have been cleared out from the dataset.

3.3 Data Visualization for Face Mask Module: After preprocessing the images are visualized to see if the preprocessing has done its work. After the training of the model with the dataset, the testing of the model is primarily done on the images of the test split, these images and their predictions are visualized to see where the model is getting its accuracy decreased.

3.4 Model Selection: To do the job of verifying face masks, we need a predicting model. To satisfy all the requirements perfectly a deep neural network is needed. Convolutional Neural Networks are fast as they don't have any cycles between their nodes, so a CNN is used in our system.

3.5 Hardware Requirements Analysis: For a temperature Verification Module, we need hardware components to obtain the task. In order to detect whether the hand is placed or not, we need to have an object detecting sensor. In order to detect the temperature contactless, we need a temperature sensor. We need a microcontroller to connect these components. We need a connecting medium.

3.6 Component Selection: To detect an object's presence contactless, IR sensors are popularly used and are mostly reliable. As far as temperature sensor requirements, we need a sensor that is reliable and can read all possible human temperatures. A study showed that a human can survive between 13.7°C and 46.2°C. That implies we need a sensor with this measurable temperature range. So now, two sensors come into the show, MLX90614, and DHT11. Comparably DHT11 has more reliability than MLX90614, so we take DHT11 for our system. The microcontroller does not have to perform any complex tasks, so an Arduino UNO would do our work. Jumper connecting wires are used to connect our components.

4 Methodology

The facemask detection module is linked with a temperature detection module and the result of both the modules is evaluated and according to them, the person is informed to be a possible corona patient or a normal person eligible to enter the building as shown (see Fig. 1). The algorithms used for both the modules are stepwise explained one after the other in the following discussion.

4.1 Face Mask Verification: Face Mask Detection is a process to identify if a person is wearing a mask or not. In order to identify containing images of people with masks and without masks, train this dataset in such a way that on detecting a face as input it should display whether the person is wearing or not. In this module, we have used the Keras library to perform face detection.

1. Import required packages.
2. Load the dataset to the data frame train and test parts.
3. Create a model using a sequential
4. Train the model with a training dataset.
5. Test the model accuracy with a test dataset.
6. Save the model in mymodel.h5
7. Load the model.
8. Open the webcam and for each frame do
9. Detect faces and store their locations
10. Using output from the previous model
11. If no face detected go to the next frame

12. Else predict the 13. Output using model

14. If mask detected show the user mask detected

15. Else display no mask

4.2 Temperature Verification: This module executes after the face mask detection module. The module takes care of detecting a person's hand and reads the temperature and checks if it is in the acceptable range.

1. The hand is detected and a signal to the temperature sensor is sent.

2. The temperature sensor detects the temperature and sees if it is optimal

3. Send the data to the python code running background from the serial monitor

4. The process from 1 and 2 steps goes on about 5 times and an average temperature is calculated

5. If the average temperature is an acceptable normal temperature then we signal the person if he has normal temperature to enter the building or not.

5 Result and Analysis

The results from the face Mask detection module and Temperature Verification module have been displayed below. First, the outputs from the face mask detection module are discussed, and then the temperature verification module.

As far as the face mask detection module is concerned, the output images are purposely taken in low quality and low light to ensure the model capability. All the outputs included regarding this particular module are taken in low light and quality video images.

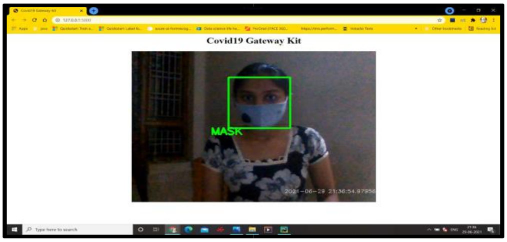

Fig. 2. Mask detected output

Figure 2 presents the result of face mask detection output when a person wearing a mask is present in front of the camera. Green color is used to indicate the acceptable output from the person. Rectangle is drawn to show that the face location has been detected successfully by the model.

Figure 3 shows the result of face mask detection outputwhen a person with no mask is present in front of the camera. The color red highlights the output from the person as unacceptable output and rectangle shows the face locations.

Figure 4 shows the output of the temperature detection module when the kit is operated with no object placed in front of it. The left screen shows the kit and the right side screen shows the output read into our module.

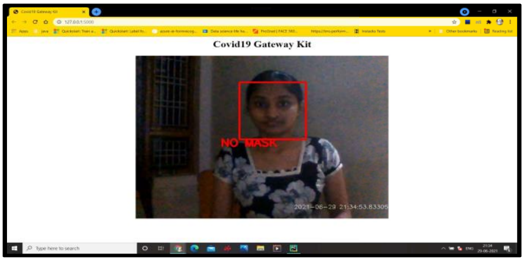

Fig. 3. Mask not detected output

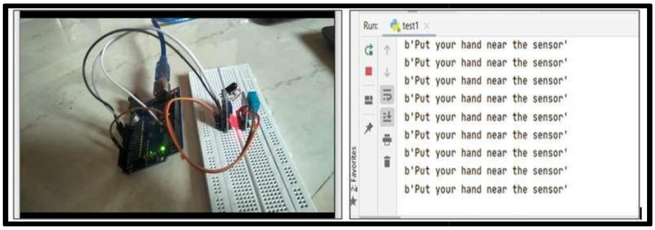

Fig. 4 Output when no hand placed

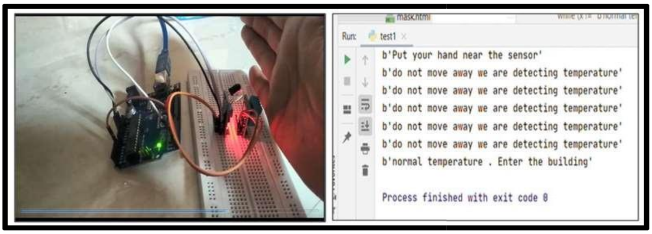

Fig. 5 Output when hand placed

Figure 5 shows the output of the temperature detection module when the kit is operated with a hand placed in front of it. The left screen shows the kit and the right side screen shows the output read into our module. When the hand is placed in front of our kit, the kit asks the user to place it for at least 5 seconds. In the meantime, we take as many readings as possible and take the average of it to get the temperature of the hand. Since the temperature is normal, we direct the user to enter the building.

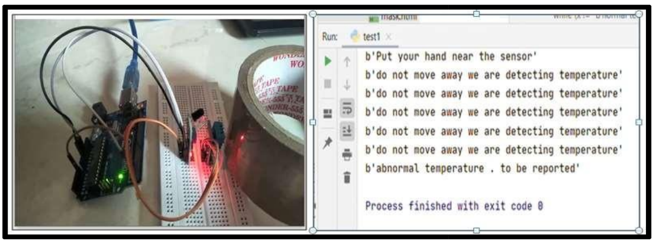

Fig. 6 Output when low temperature object placed

Figure 6 shows the output of the temperature detection module when the kit is operated with a hand placed in front of it. The left Figure 6 shows the output of the temperature detection module when the kit is operated with a hand placed in front of it. The left screen shows the kit and the right side screen shows the output read into our module. When the hand is placed in front of our kit, the kit asks the user to place it for at least 5 seconds. In the meantime, we take as many readings as possible and take the average of it to get the temperature of the hand. Since the temperature is abnormal, we instruct our team that the temperature is abnormal.

6 Comparative Analysis

The face mask detection feature of the proposed system has succeeded in identifying the face masks of the persons entering the building to an acceptable extent. In contrast to the present models, it can effectively detect a face mask from low-quality videos. Although the system works great with low-quality cameras, the problem arises when it has to detect masks of dark color worn by a person with a dark complexion skin tone. The system has yet to increase its accuracy in this regard. The overall performance has been acceptable.

Table 1. Comparative Analysis between MLX90614 and DHT11

MLX90614 sensor	**DHT11 sensor**
Popular sensor for contactless temperature measurement	Popular sensor for reliable temperature measurement
High cost + Low reliability	Low cost + Better reliability
Temperature range: -70 to 380°C Accuracy : ±0.5°C	Temperature Range: 0-50°C Accuracy : ±2°C

The contactless temperature measurement feature has been evaluated to be reliable and robust. The existing models of contactless temperature measurement have used MLX90614 sensors to obtain the temperature measurement. A small table based on the comparative analysis between MLX90614 and DHT11 is given in the table (see Table 1). Our system uses the DHT11 sensor to obtain the same task. With MLX90614 sensors, it is observed that they are highly unreliable and expensive. MLX90614 needs a stable voltage without which it does not function well and often a problem arises when there is no analog to digital converters attached to the Arduino if there is more than one analog device attached to it. DHT11 sensors have been widely used in the market for their reliability for contacted temperature measurement. Since we needed a contactless experience, the model goes with an error of about 2°Celsius, and the distance between the hand and kit is evaluated to perform well with 2 cm. Comparing this to the existing contactless temperature measurement, MLX906114 has a pretty similar distance range between the hand and the sensor. So using the DHT11 has completed the task of measuring contactless temperature measurement reliably. Another sensor used called the IR sensor is accurately detecting the object placed in front of it. But a problem is that it is unable to distinguish between the hand and other objects.

7 Conclusion

This paper proposes a new model for automating the covid19 preventive measures at public places. The proposed system 'Covid19 Gateway Kit' gives a solution to the traditional manual verification of face masks, and temperature verification of people entering the building and replaces it with an anywhere installable software kit. Since social distancing has become a huge necessity to avoid coronavirus, this system effectively helps in reaching the goal of social distancing.

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