International Journal of Latest Engineering Research and Applications (IJLERA) ISSN: 2455-7137

Volume – 08, Issue – 10, October 2023, PP – 37-49

Standards Improvement for Face-Mask Detection in an Elevator Prototype to Prevent Covid 19 Spreading

Laila Damri
ENSA of Berrchid, First Hassan University, Morocco

Abstract: In the context of the COVID-19 prevention this article proposes an upgrade of a reliable method to detect in several conditions the wearing mask in some critical places. This paper contains the new innovative option which we added to the elevator prototype system the masked Face Recognition. This makes face recognition a very difficult task since certain parts of the face are hidden, we propose a reliable method based on discard masked region and deep learning-based features to address the problem of the masked face recognition process. This article presents the improvement works carried out in the operation of an elevator to improve the rate of prevention of covid, by proposing a study case of a microcomputer – based elevator system prototype, using DC motor, gear, controller circuit etc., that carries out an experimental implementation with the simulation software. In otherwise, a thermal detection system is implemented to react in case of detection of abnormal temperature and save this information in a database.
Keywords: Artificial intelligence, Deep learning, Embedded systems, Face recognition, Masked face detection, Thermal detection.

I. INTRODUCTION

As the worst pandemic in the age of globalization, COVID-19 has confronted our societies with unexpected threats and challenges. The virus has taken many lives and destroyed livelihoods worldwide. As an example, until now day, covid has taken more than 5 million lives from more than 250 million cases.

Our world is now living in a whole pandemic situation that became our reality and that we are required to tolerate and accept. wearing masks, keeping our distances, losing members of our families, or even enduring the consequences of healing from the covid-19 represents some of the main consequences that we are supposed to handle by changing our habits and customizing our environment.

Elevators represent a part of our environment that became an essential tool in our lives, we now find them in every single building therefor it was necessary to make sur that a bunch of restrictions were respected by adding some protective modifications such as:

- Not having the accessibility to the elevator if the person is not wearing a mask.
- Not been able to close the elevator's door if the maximum number of people is acceded.
- Having the ability to take everyone's temperature and save it in a data base.

These modifications were added in a hope of reducing the covid-19 contamination that's increasing every day and that we are working on managing or controlling if we are allowed to say so.

In this article, we first recall various existing searches and methods of face detection and recognition. These methods were source of inspiration to propose an improvement elevator system as case of study. We present an overview of our elevator system prototype: schematic simulation and hardware design. The mean idea is to improve the elevator system performances and make it able of reacting according to basic safety standards as wearing mask and continually observe the person temperature. And finally, Experimental results on Real-World-Masked-Face-Dataset show high recognition performance.

II. FACE DETECTION AND RECOGNITION DEVELOPMENT

As a fundamental task in computer vision the Object detection is broadly applied in the applications of face detection, pedestrian detection, and sign detection. Face detection is always a hotspot in object detection. Due to the outbreak of the pandemic, face mask detection has attracted much attention and research. However, this area was the focus of researchers even before this pandemic and their work has formed the basis for the advancement of research today.

We will start by the study published by R. Chellappa and al. [1], that describes the face recognition as an important tool in our daily life and individual and national security. For example, it helps to fight the crime which is seen as the most important problem facing the country. Furthermore, commercial applications of this technology have received a growing interest (credit card compagnies ...), and obviously other sectors. They show also the segmentation of a face region from a still image or video as the key of a good face recognition. A multitude of promising techniques are available for recognition.

W. Zhao and al. proposed in [2] an efficient automatic method of faces recognition and verification based on two techniques: PCA (Principal Component Analysis) [3] and LDA (Linear Discriminant Analysis) [4]. The mean idea is to improve the rate of the faces recognition even with hard conditions, by combining PCA and LDA to improve the performances over the pure LDA based method. This improvement was demonstrated through some local experiments and FERET test [5].

In deep learning, a convolutional neural network (CNN, or ConvNet) [6] is a class of deep neural network, most commonly applied to analyse visual imagery. They are also known as shift invariant or space invariant artificial neural networks (SIANN), based on the shared-weight architecture of the convolution kernels or filters that slide along input features and provide translation equivariant responses known as feature maps. According to the proposed recommendations and improvement strategies, the current object detection methods can be divided into two categories: two-stage detectors and one-stage detectors. For example, the tow-stage detectors method first generates a large number of region proposals for each image through a heuristic algorithm or CNN and then classifies them and regresses these candidate regions. As the earliest object detection method based on deep learning, R-CNN belongs to a two-stage detector. R-CNN firstly adopts selective search to generate a sparse set of candidate regions. Then, it extracts the features of the region through CNN and finally determines the class of each object by SVM and fine-tunes the bounding boxes using linear regression. Although the two-stage detectors have good detection performances, their training phases are complex, and the testing speeds are usually slow, so they are not suitable for the real-time requirement.

The MRE hypothesis was created and applied by Cui and Singh for month-to-month streamflow prediction with spectral power as a random variable [7]. That system restricts the growth of COVID-19 by finding out people who are not wearing any facial mask in a smart city network where all the public places are monitored with Closed-circuit Television (CCTV) cameras. Firstly, CCTV cameras are used to capture real-time video footage of different public places in the city. From that video footage, facial images are extracted, and these images are used to identify the mask on the face. Another model for face detection using semantic segmentation in an image by classifying each pixel as face and non-face. effectively creating a binary classifier and then detecting that segmented area.

Hang Du and al. [8] discuss in their article the difficulties encountered in masked face recognition, because of the lack of data. They propose a training method Near-InfraRed to VISible (NIR-VIS) approach based for heterogeneous face recognition. This approach combines the Near-InfraRed (NIR) probe face image [9] with a VISible (VIS) gallery face image [10]. It is an improvement of research work of NIR-VIS face recognition proposed for example on [11, 12] that present, in addition of the previous searches, a heterogeneous semi-siamese training (HSST) to maximize the mutual information shared by the face representation of masked NIR and VIS images from two views. They also employ a 3D face reconstruction-based method to synthesize masked faces for addressing the lack of masked face data.

But [13] is the most helpful research for us, the authors proposed a method for slide doors access system using face recognition technique by using python programming and from OpenCV library Haarcascade method. The system is designed to detect the faces in a real-time video and to determine whether the person wears a face mask or not. Using the detected data, system can decide whether the concerned person can be allowed or not allowed. This research basically consists of, a camera placed in front of door, the camera sends video frames to OpenCV running on a Windows PC. If OpenCV detects a face it will capture the image of the people entering public places, then the detected face image is sent to the system to be compared (tested) whether the person wears a face mask or not using Tenser flow. After the data processing, TensorFlow will send the result to Arduino whether to open the door or Not as shown in. (More details undermentioned).

III. OVERVIEW OF IMPROVED ELEVATOR SYSTEM

The elevator control system overview (Fig.1) consists of a floor where passenger wants to visit and where the elevator car moves it either upward or downward direction. An arrival sensor detects the arrival of the elevator to the respective floor. The floor buttons are used to take the elevator at that respective floor. The floor lamp is used to show the indication of floor and direction lamp shows the direction of elevator movement, whether it is in upward or downward direction. The elevator button is used for moving the elevator car either in upward or downward direction. When the elevator switch is pressed, the elevator car is moved either in upward or downward direction. A DC motor, based on the switch pressed. either moves in forward and reverse direction to move the elevator in either upward or downward direction respectively. When the elevator car stops in particular floor. the door of the elevator is opened for the passengers to come out of or enter into the elevator car. The arrival sensor is used in every floor for detecting the elevator car. when the car is reached to the particular floor. this arrival sensor detects the elevator car and stops that car. also there is a system for the doors (the door of the elevator and the door of the car) there are two sensors detect if the exterior door is opened or closed and one to know if the door of the car is opened or closed to add conditions and the weight sensor cause users must not exceed a particular weight and finally the laser sensor to avoid the closure of the door while the users are entering or going out of the elevator.

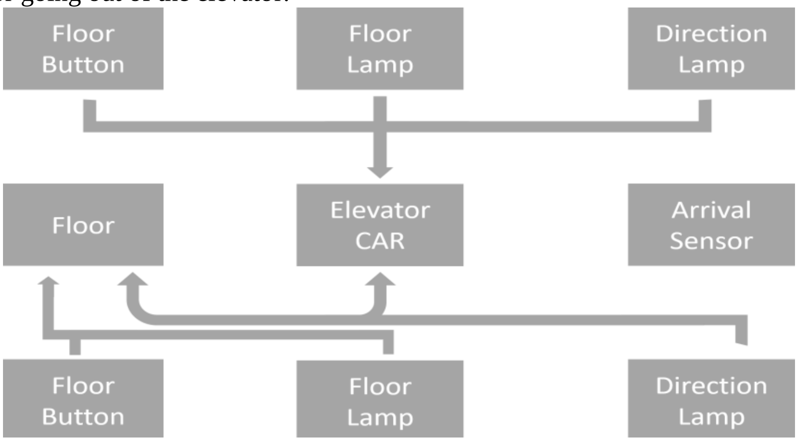


Fig. 1 Elevator system overview

When a user presses any button, the elevator button sensor sends the elevator button request to the system, identifying the destination floor the user wishes to visit. When any new request comes, this new request is added to the list of floors to visit. If the elevator is stationary the system determines in which direction the system should move to give service to the next request. The system commands the elevator door to close. When the door has closed, the system commands the motor to start moving the elevator, either in up or down direction, based on switch pressed.

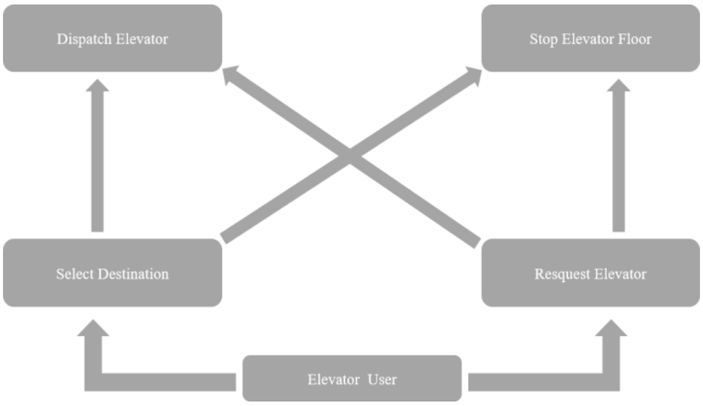


Fig. 2 Elevator dispatching strategy

When the elevator moves between floors, the arrival sensor detects that the elevator is approaching a floor and notifies the system to stop the elevator and open the door of the elevator system.

The (Fig.2) shows how elevator systems works when several requests come from users.

3.1. Systematic Simulation Work

The first step of this work is to simulate the PC based elevator control system. The simulation has been done by using Proteus professional software, which is Avery powerful software to design and simulate any practical system.

The (Fig.3) shows the overall schematic diagram. It comprises a controller unit (ATmega32 microcontroller), an LCD display unit, few LED indicators, few optical sensors, virtual terminal connected to the virtual serial port emulator and RS232serial communication port and DC motors.

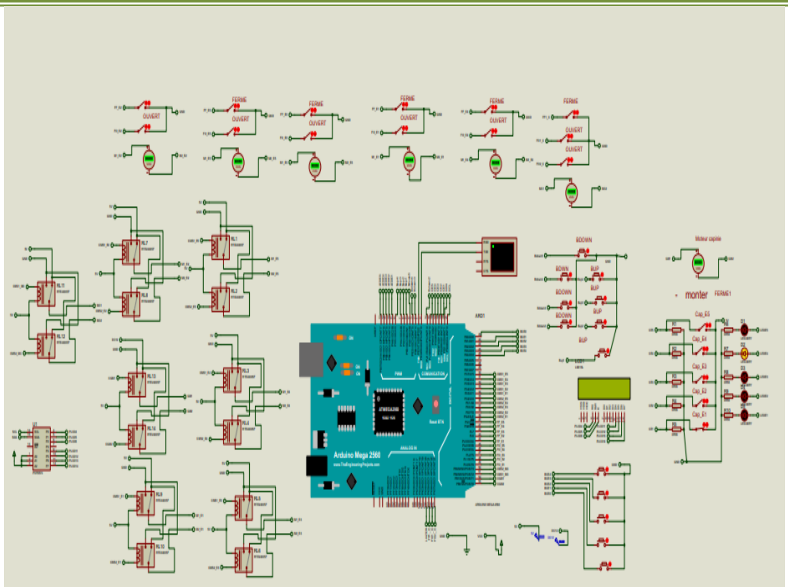


Fig. 3 Elevator's overall schematic diagram

The flow chart for the elevator control system is shown in the (Fig.4). At the beginning, microcontroller checks the status of the floor keys having individual identification numbers. If the floor key is pressed from the 2nd floor, then it has the option to go up or down depending on the key status inside the car. If down key is pressed from inside the car, then the car only accepts the down command and then the motor rotates accordingly to go downward. Similarly, if the up key is pressed from inside the car, then the car only accepts the up command and then the motor rotates accordingly to go upward. On the other hand, if the floor key is pressed from the 1st or 5th floor then it has only one option either to go up or down respectively. User can press any key from inside the car, but it is very important that the controller always takes the right decision and executes the right command one after another without any making mistake. The program is written in such a way that the microcontroller does not do any mistake.

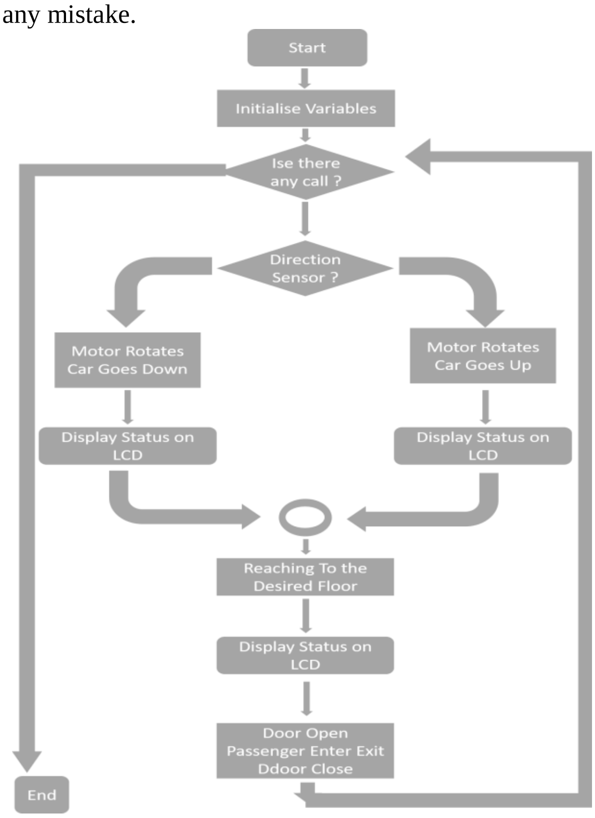


Fig. 4 System operation algorithm

3.2. Hardware of the Elevator Control System prototype

The main aim of this section is to implement the elevator control system using PC and ATmega2560 microcontroller ((Fig.5) and (Fig.6)).

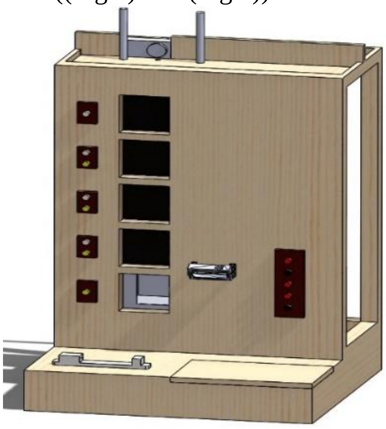


Fig. 5 3d conception in solid works

Fig. 6 Elevator prototype

The DC motor is connected with a gear set up; one wheel is attached with this gear for moving the elevator rope in both upward and downward direction. One end of the rope is connected with gear wheel system and another end of the rope is connected with the car module.

In this five-floor elevator control system, two sensors are used in every floor, one for stopping the elevator car in respective floor and another for opening and closing the elevator door to get in and get out of the passengers at the respective floor.

IV. UPGRADE TO REDUCE CONTAMINATION IN THE ELEVATOR

This section will be divided on several parts. The first one will present the algorithm of mask detection. In the second one, we will mention the different tools and software used in this work, before presenting the method used to react on mask detection algorithm on the elevator system. Also, we add and explain option that can help blind people to follow different instructions from the system to assure their safety. In the last part, will explain the thermal detection added to the whole system to store the person's temperature with all useful informations.

4.1. Mask detection

To recognize a human face, we need its complete facial features.

A masked face becomes difficult to identify because it provides incomplete facial features. However, modern technology has come to our rescue. With the help of artificial intelligence and machine learning. We can develop different models for different applications (like classification, processing, etc.) and get accurate results. However, it requires several properties such as face orientation, eye position, mask position, face position bounded by a shape like a square:

shape, i.e. H. Square, mark the position of the face, mark the shape of the face, including front left, front left, front right, and front right.

The center of the eye is masked as the position of the eye. The position of the mask with details is necessarily determined by the shape, ie. H. Rectangle marker. Different types of masks on the market: artificial masks or masks without logos, hand masks, etc.

We are going to examine an application related to computer vision, for detecting masks to help ensure the safety of others thanks to OpenCV which will allow controlling access to the elevator via artificial intelligence.

The main challenge is to correctly detect the face from a live video and then to identify if it is wearing a mask.

Face detection requires expression recognition and pose estimation, it is a very difficult task as each face has its own shape, size or color.

The proposed method should also detect a face with movable mask, we need to train a model by loading our face mask detection data, then deploy the model by loading the mask detector, then perform face detection and classify each face with or without mask.

We will look at the dataset we will use to train an adaptable face mask detector for the situation.

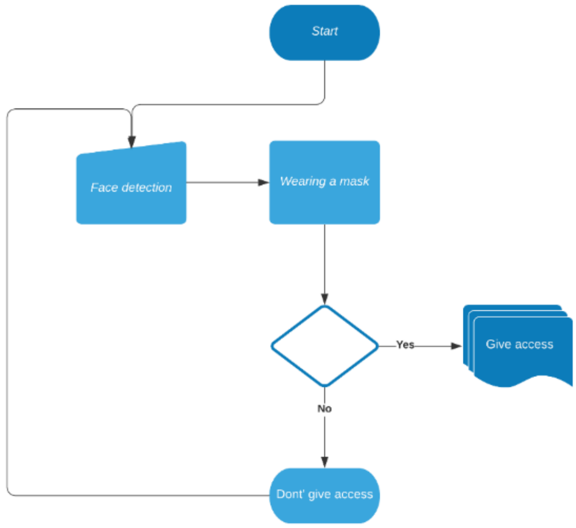


Fig. 7 Algorithm of mask detection

A rectangle will be placed on each face once detected, then the distance between different parts of the face will be calculated to decide if the person is wearing the mask or not (Fig.7).

We will be using basic machine learning packages such as TensorFlow, Keras, OpenCV, and Scikit-Learn.

4.2. Software requirement

4.2.1. Keras

Keras gives fundamental thoughts and building units for the creation and transport of ML arrangements with high iteration speed, he helps to compile the overall model.

4.2.2. OpenCV

An open-source library for recognizing objects, recognizing faces, following camera gestures and actions...

4.2.3. TensorFlow

TensorFlow, an interface to express machine learning algorithms, including sentiment analysis, computer vision, information retrieval ...

4.2.4. Scikit-learn

Scikit-learn is a free Python library for machine learning, simple and efficient tools for predictive data analysis.

4.3. Method used for masque detection:

By using TensorFlow to build a neural network model and train it on a dataset of people with and without masks, and to improve our detection model, we have integrated a database of several people wearing masks for more precision also our photos.

- To detect if a person is wearing a mask or not, follow the steps below:
- Face detection
- Application of the mask model

We start by calculating the uncovered emptying part, if it is sufficient the detector provides for the person wearing a mask.

Our custom mask detector works equally well in all situations.

4.4. Overcrowding

Overcrowding or crowding is "the presence of more people or things in a space than is comfortable, safe, or permissible".

In pandemic this factor is one of the most serious ones, because we don't have a big space to respect the social distancing and to keep at least 1 meter between users.

To detect how many persons in the elevator, we used the image processing to recognize faces going through the last model we generate, and we create counter to count the faces in the image (Fig.8).

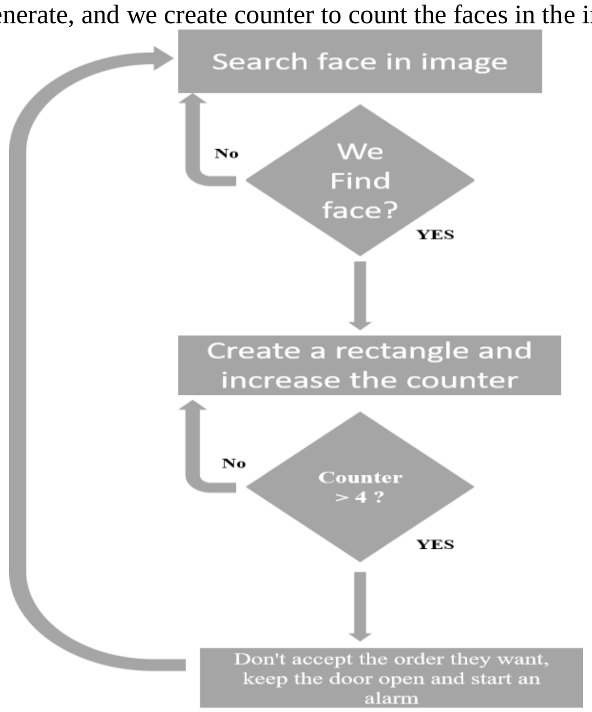


Fig. 8 Algorithm of overcrowding detection

4.5. The blind

According to the World Health Organization. the number of visually impaired people in the world is currently more than 285 million, a number that is expected to triple in the next 30 years.

The easy way to give notification to blind person is by the sound. In our program we added the possibility to play sounds predefined like «put your mask please», «the elevator is overcrowding», «welcome ».

To play this sounds we use Pygame is a free Library that makes the development in real time very easy with Python language.

4.6. Thermal detection

The technology used We carried out the test on the thermal camera of the Adhua technology brand. The two-lens camera first detects the person with lens 1, then registers their first and last name and then their arrival time.

Secondly, lens 2 reveals the person's temperature and then displays the temperature.

The library used:

```
import cv2
import pytesseract
import numpy as np
from PIL import ImageGrab
import time
import Crop
```

Our algorithm is based on the principle of creating a smart elevator that only gives access to people wearing a mask. The number of people can be configured as needed, for our prototype the number is set for 4 people.

In the technology used we carried out the test on the thermal camera of the Adhua technology brand. In this camera with two lenses :

- First, we used lens to detect the person first with lens 1, which allows the detection of the mask to be launched and whether the person is wearing it or not.

- Second, lens 2 reveals the temperature of the person we have proposed a new method that allows us to get the information of the temperature to decide whether the temperature of the person is normal or it exceeds the standards to take an image to the groups of people using the elevator to inform them afterwards to do a covid test.

The smart elevator model can also be used in a company to have personal information to send messages to each person according to these coordinates. After capturing the thermal image from the camera, the resulting image is saved as a jpg image, Python allows to extract the original values of the photo and thermal sensors converted into temperatures. This makes it possible to deduce the numerical value of the temperature. Our new method makes it possible to extend it to the reading of several digits.

Our method consists of first detecting the face of the person by a face detector script then saving the image in jpg form, after that cropping the image to dimensions allowing the digital value of the thermal camera to be kept in the frame with the face of the person by a specific script called at the end of the first one, then launching a last script which is a digit's detector which allows to extract the numerical value of the temperature from the cropped image. The method shows accuracy when detecting numerical values of temperature.

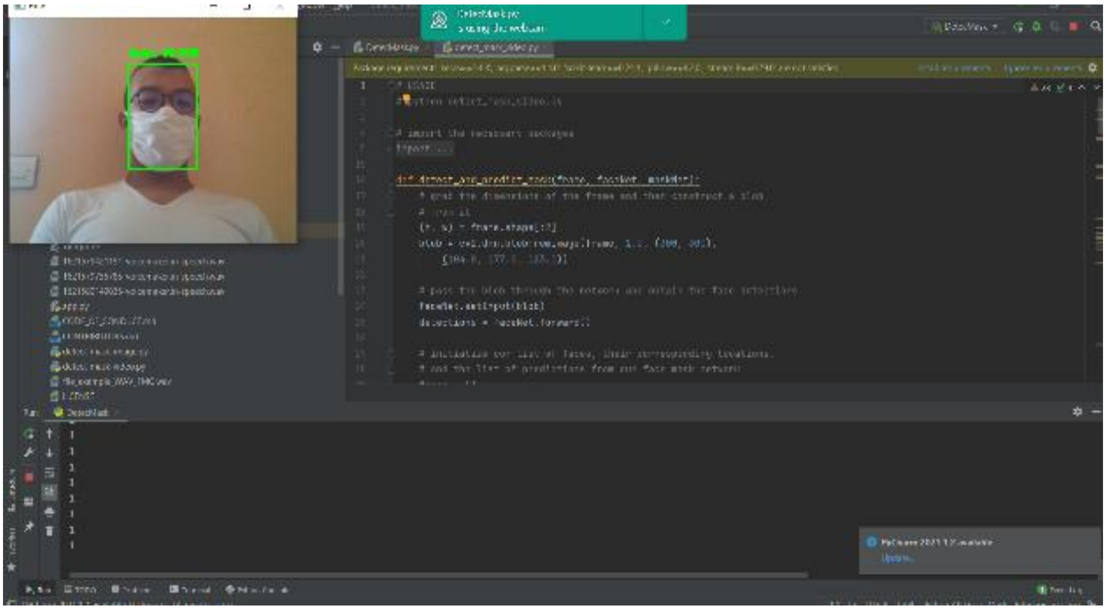
V. EXPERIMENTATION AND RESULTS

All these experiences are done on a laptop computer equipped with an i5-8265U CPU (3.9ghz) processor and a 8GB ram with an Intel® UHD Graphics 620 graphics card; the PyCharm Community Edition 2020.3.5 software containing python 3.9 in which we did this research either the development or the implementation of the code.

For all test cases, this system was tested firstly using displaying message on serial monitor afterwards with the elevator prototype and it worked well.

5.1. Face detection:

With Mask



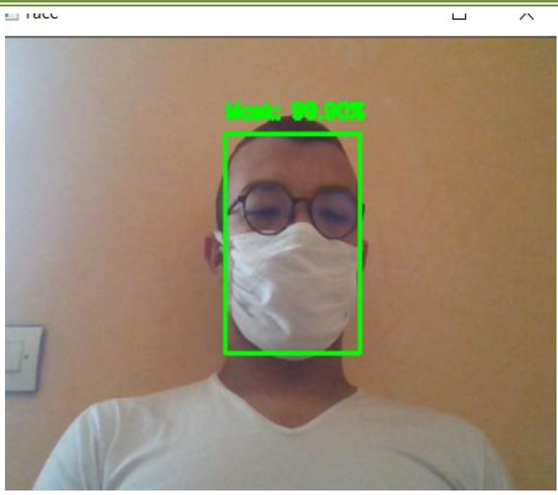
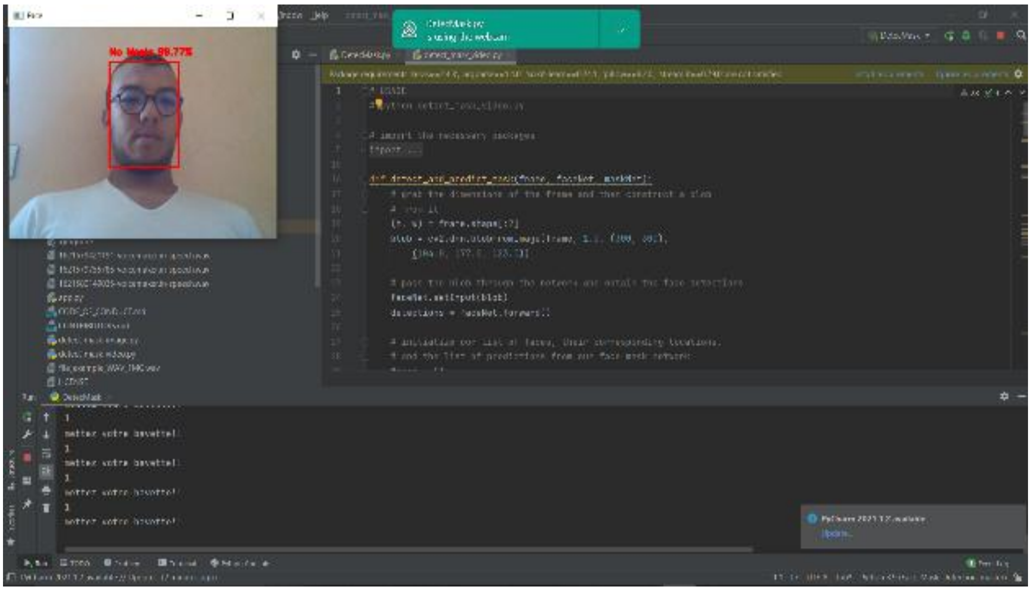


Table 1 Experience test of mask detection (with mask)

Without Mask



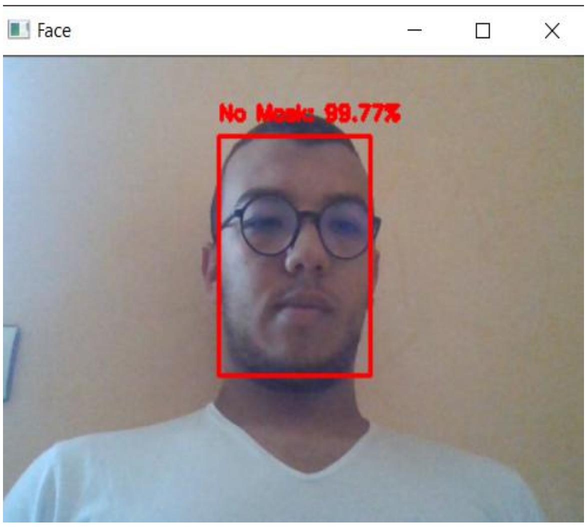


Table 2 Experience test of mask detection (without mask)

In our experimentation, we start with testing the efficiency of the mask detection algorithm. As shown in Table 1 and Table 2, the algorithm was able de detect with a high precision that reached 99,90% the recognition without mask and 99,70% the detection of the mask on the same case of study.

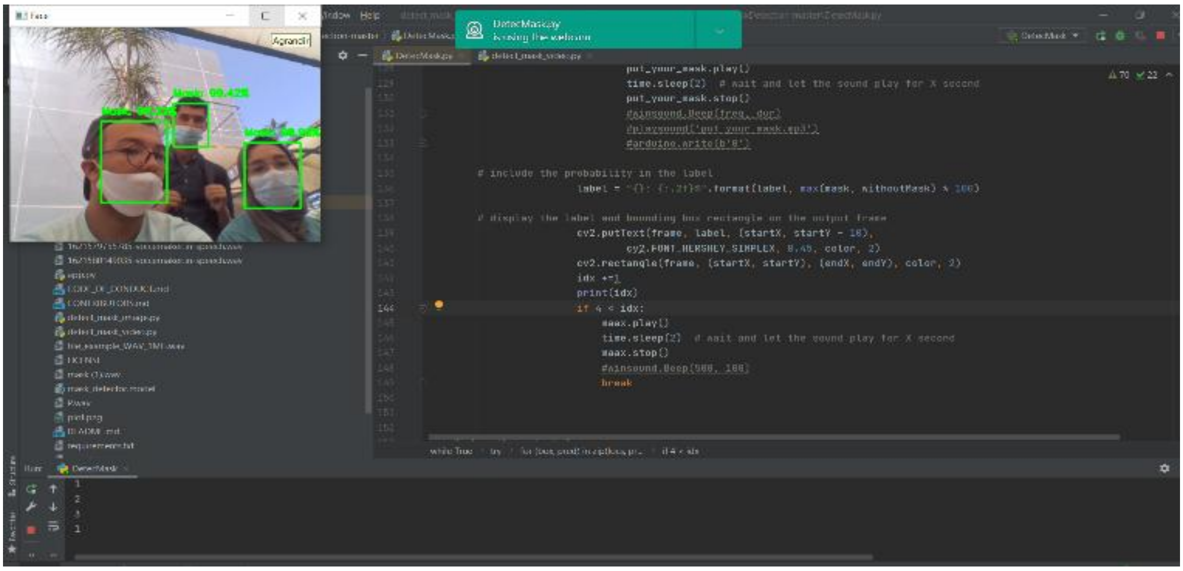
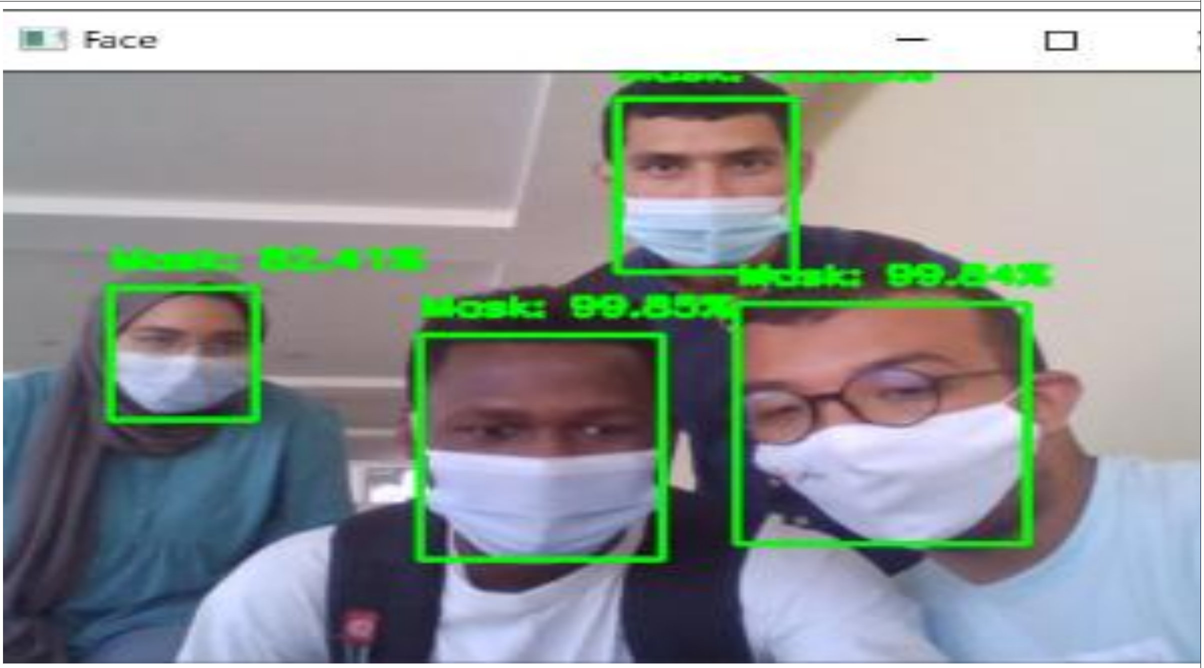
Less Than 3 People



Table 3 Test of overcrowding (less than 3 people)

More Than 3 People


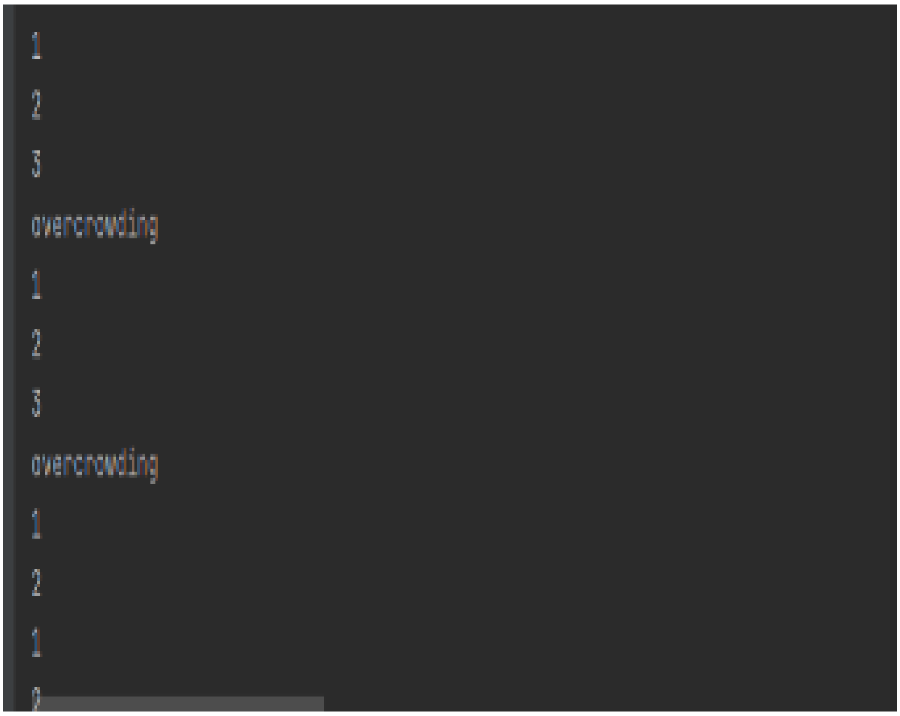


Table 4 Test of overcrowding (more than 3 people)

Then, as shown on Table 3 and Table 4, we test the elevator system prototype with the algorithm of mask detection implemented to increase the security when eventually want to take the elevator (overcrowding). The results show that the system reacts to the constraints imposed by the algorithm to respect a limited number of persons.

5.2. Thermal detection:

The second part of our experimentation, show the results about the thermal detection. To test the reliability of the system we tested with several thermal image.

As shown in (Fig.9) and (Fig.10), the final result is displayed on the console as follows:

Fig. 9 Thermal detection

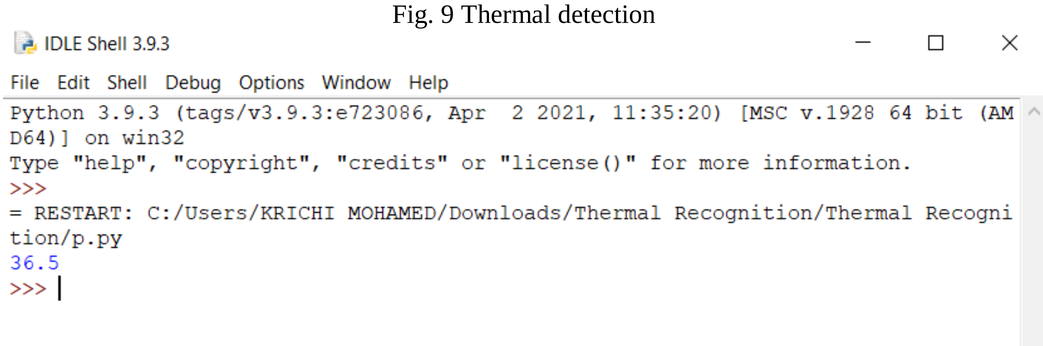


Fig. 10 Store the information from the Thermal detection

The person’s temperature is measured, and an image capture es saved in a database.

VI. SUGGESTED METHOD

The proposed system detects if a person is wearing a mask and knows the temperature, and follows safety instructions in case of abnormal temperature, in this case, saves a photo of the person; for face recognition using TensorFlow, in order to build a neural network model and use the wear to train it on a dataset of people wearing masks, and to improve our recognition model, we integrated a database of multiple people wearing masks to improve accuracy, as do our images.

We first count the uncovered part of the face, and if enough, the detector provides it for the person wearing the mask. Our custom mask detector works equally well in all situations; if it identifies a person.

In addition, its temperature and the health requirements of the system allow the elevator doors to be opened and closed, and in the absence of a mask, an audible alarm will sound for the blind.

VII. CONCLUSION AND PERSPECTIVES

As mentioned previously we are working on a microcomputer-based elevator that we brought many modifications to, which the most remarkable one is the masks detection using an application bound to a computer. this added value is going to allow us to ensure that every single person using the elevator is wearing a mask by keeping the elevator door closed as long as the face detected in not wearing a mask, if so, a green rectangular is going to appear on the screen installed outside of the elevator and the doors are maintained open for a while. And the temperature of each person who enters the elevator will be measured is stored in a database accompanied by a screen of his image. This way we guarantee that the elevator user is in a way protecting himself and other users.

In this article we are providing a prototype of an improved system, able to assure basic protection and COVID 19 prevention. However, we still working to bring to this system more functionalities, specifically on the external exploitation of the information (face recognition from masked face combined with temperature measured) collected (big data). The goal of our next work is to bring improvement to this data base to allow to keep some traceability (persons presents and their identities) if ever cases of COVID 19 are identified in the elevator area.

REFERENCES

[1] R. Chellappa, C. Wilson & R. Sirohey. Human and machine recognition of faces: a survey. *In Proceedings of the IEEE* (vol. 83, pp. 705 – 741), 1995.

[2] W. Zhao, R. Chellappa & A. Krishnaswamy. Discriminant analysis of principal components for face recognition. *In Proceedings Third IEEE International Conference on Automatic Face and Gesture Recognition* (pp. 336-341). DOI: 10.1109/AFGR.1998.670971, 1998.

[3] Rasmus Bro, A. K. S., A. (2014). *Principal component analysis. (*In The Royal Society of Chemistry Journal, 2812–2831. DOI: 10.1039/c3ay41907j, 2014).

[4] A. J. Izenman. *Linear Discriminant Analysis. In: Modern Multivariate Statistical Techniques*. (Springer Texts in Statistics. Springer, New York, NY, 2013).

[5] P. J. Phillips, Hyeonjoon Moon, S. A. Rizvi & P. J. Rauss. *The FERET evaluation methodology for face-recognition algorithms*. (In IEEE Transactions on Pattern Analysis and Machine Intelligence (vol. 22, no. 10, pp. 1090-1104). DOI: 10.1109/34.879790, 2000).

[6] J. Teuwen, N. M. (Ed.). *Handbook of Medical Image Computing and Computer Assisted Intervention*, (2020).

[7] Cui, H. & Singh, V.P. *Application of minimum relative entropy theory for streamflow forecasting*. (Stoch Environ Res Risk Assess (vol 31, pp 587–608), 2017).

[8] H. Du, H. Shi, Y. Liu, D. Zeng. & T. Mei. Towards NIR-VIS Masked Face Recognition. *In IEEE Signal Processing Letters* (vol. 28, pp. 768-772). DOI: 10.1109/LSP.2021.3071663, 2021.

[9] S. Z. Li, et AL. A near-infrared image based face recognition system. I*n 7th International Conference on Automatic Face and Gesture Recognition* (pp. 455-460). DOI: 10.1109/FGR.2006.13, 2006.

[10] X. Shu, L. Beckmann & H. F. Zhang, Visible-light optical coherence tomography: a review. *In Journal of Biomedical Optics* (vol. 22(12)), DOI: 10.1117/1.JBO.22.12.121707, 2017.

[11] X. Liu, L. Song, X. Wu & T. Tan. Transferring Deep Representation For Nir-Vis Heterogeneous Face Recognition, *In Proceedings Internationa Conference Biometrics* (pp. 1–8), 2016.

[12] He R., Wu X., Sun Z., and TanT. (2017). Learning invariant deep representation for NIR-VIS face recognition, *In Proceedings* 31st AAAI *Conference* Artificial Intelligence (pp. 2000-2006).