Contents lists available at Science-Gate

International Journal of Advanced and Applied Sciences

Journal homepage: http://www.science-gate.com/IJAAS.html

Face mask management system for the control of supplies of medical personnel in the private sector

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ARTICLE INFO

Article history:
Received 25 July 2022
Received in revised form
2 January 2023
Accepted 24 February 2023

Keywords:
Algorithm
Biosecurity
Surveillance camera
COVID-19
WHO
Pandemic

ABSTRACT

In late December 2019, COVID-19 changed people's lives by forcing people to maintain social distancing and wear a face mask on a mandatory basis, because the virus caused by SARS-COV-2 is immensely contagious and can be easily transmitted between people who have direct contact. In the month of May, the virus infected more than 153 million people saturating the health system worldwide, therefore, it was established as a preventive measure to maintain social distancing in public places and use the face mask in a mandatory way to help control COVID-19, since through these measures the probability of contagion is greatly reduced since it protects the nose and the person's mouth. In view of this problem, this article made the approach of a system of administration of face masks for the control of supplies of medical personnel in the private sector, in such a way that the system analyzes several people who enter the place and shows if they use the mask correctly through a monitor, requiring to respect this important biosecurity measure, in addition to being able to make a report detailing the supplies of face masks to send to the administrator in charge. Through the development of the system, it is determined that the system works in the best way and presents a percentage of efficiency of 97.12% in detecting the face masks of medical personnel.

1. Introduction

On December 31, 2019, in China, specifically in the city of Wuhan, a health emergency happened that completely changed the lives of people around the world (Cruz et al., 2021) where the authorities of this country managed to identify the cause of this disease is due to a new strain of coronavirus and that is why governments decided to establish some biosecurity measures where it was prioritized to maintain social distancing and use of the face mask in a mandatory way (Azócar-Gallardo et al., 2021).

These new biosecurity measures were regularized in a mandatory manner so that they are complied with by all citizens because this virus caused by SARS-COV-2 is highly contagious (Shereen et al., 2020) and can be easily transmitted between the direct contacts of an infected person with other people around them. This characteristic of the virus caused it to spread rapidly through all countries and due to this health emergency was announced as a pandemic on March 11, 2020, by the World Health Organization (WHO) (Roco-Bazáez, 2021). So much was the magnitude of this virus that until the month of May 2021, it infected more than 153 million people worldwide (Amsalem et al., 2021), representing 64.47% of all people infected with COVID-19 is that moment, complicating the entire health system worldwide and exposing the terrible health situation that was lived throughout the country (Shadmi et al., 2020). As the health system became saturated worldwide, it was established as a preventive measure to maintain social distancing in public places and use the face mask in a mandatory way to contribute to the control of COVID-19, since through these masks the number of saliva emissions and respiratory microdroplets of individuals who

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have COVID-19 can be reduced (Shen et al., 2021). Therefore, it is important to use the mask to avoid the contagion and transmission of the virus, it would even help us avoid getting infected by those asymptomatic people who do not present any symptoms but in the same way continue to infect (Correia et al., 2020), even so, there are people who take off the mask in the public space without considering that within the vulnerable groups before the COVID-19 pandemic are the elderly who can contract the disease and present severe symptoms (Vega Rivero et al., 2020).

In Peru, when the health system at the national level became saturated, many companies paralyzed their work and stopped producing merchandise or providing services in their field, this undoubtedly brought a great economic loss to various companies, representing approximately 27.14% of their annual profits (Shaikholla et al., 2021). It also includes health system workers who worked constantly to combat the COVID-19 virus, representing approximately 90.74% of the workforce in the country in 2020 (Esenarro et al., 2021), which unfortunately was not enough because they did not have the medical equipment to face this pandemic. In addition, it should be added that in Peru there is a high rate of labor informality that is around 46.5% of the Economically Active Population (EAP), where low incomes prevail, and scarce social protection stands out (Soto et al., 2020). Given the need for people to have to work to survive in the middle of the pandemic, economic activities temporarily paralyzed by the pandemic had to be reactivated (Gomero-Fanny et al., 2020), which led to formal companies having to take care of their workers so that they do not get COVID-19 since it could infect all the staff in the company. Therefore, it is necessary for health center workers to use face masks to enter their workplace, otherwise, they must provide them with face masks so that they can continue with their work activity.

The objective of this research work is to carry out the approach of a face mask management system for the control of supplies of medical personnel in the private sector, in such a way that, if the health worker forgets to wear his face mask, the health center will provide him with a face mask and automatically register it in his system to be able to control these supplies and be able to buy more if it is that would be missing. With this, the formation of a source of contagion of COVID-19 would be avoided since being in a closed area the virus could be transmitted quickly. For the operation of the system, the medical personnel will be analyzed through a surveillance camera located at a height greater than 1.90 meters, then with a program executed by Raspberry Pi 3 model B the face mask of the individual will be recognized otherwise it will give notice to the administrator so that he can provide a face mask and that information will be automatically stored in the system. All this programming was developed with Python, a friendly and widely used programming language.

In section 2, the literature review was made indicating some research work regarding the proposed system. In section 3, the methodology will be made into a flowchart of the system. In section 4, the detection system shall be performed. In section 5, the results that are generated according to the tests carried out with the administrative system will be indicated. In section 6, the discussion will be presented, indicating the importance of this work with respect to other works. Finally, in section 7, the conclusion and recommendation obtained from the administrative system will be presented.

2. Literature review

To know if a person really has COVID-19 it is necessary to perform a molecular test or an antigen test, even if the results take time to show, therefore, it is necessary to correctly use the face mask since this virus is silent and we do not know which person could be infected since there are asymptomatic people, therefore, the corresponding care must be maintained to avoid being infected with this virus, enforcing the use of a face mask using a system that through surveillance cameras can detect its correct use every time health personnel wish to enter. For example, Srinivasan et al. (2021) mentioned that normally in many places social distancing and the use of face masks are controlled manually, being a vulnerable and dangerous way for the staff in charge due to the large number of people with whom they have contact and even worse that they do not know that people may be infected with COVID-19, that's why they proposed developing a COVID-19 monitoring system that uses social distancing and face mask detection in surveillance video datasets. The proposed method involves using a convolution neural network (CNN) using YOLOv3, a dual-shot face detector (DSFD), and a MobileNetV2-based binary classifier in surveillance video datasets. Obtaining, as a result, an efficiency of 91.2% of detection, concluding that this system is a viable solution to control social distancing in public areas, where it is very difficult to control them manually due to the large agglomeration of people.

Vinh and Anh (2020) clarified that from the beginning of COVID-19 until the appearance of the virus in various countries, safety protocols were established to protect themselves from the virus, one of them being the face mask since it covers the part of the nose and mouth, so it is important that people use the face mask inside the factories, supermarkets, departments or work offices to prevent work personnel from catching COVID-19, that is why they proposed to develop a real-time face mask detector system that uses the YOLOv3 algorithm and Haar's cascade classifier. The proposed method involves using an algorithm to detect face masks using a Haar cascading classifier to detect the person's face and the YOLOv3 algorithm to detect the face mask. Obtaining as a result an efficiency of 90.1% of detection, concluding that the algorithm proposed by the authors uses a processing technique that

improves the quality of the image to have greater accuracy.

Draughon et al. (2020) explained that in the United States, the COVID-19 pandemic spread at an alarming rate in public places due to the lack of interest on the part of people in respecting the biosecurity measures declared by the government, being necessary to adopt strategies to carry out an adequate control to respect the biosecurity measures and to be able to follow up on the mandatory use of face masks in public places or places where there is a greater concentration of people, which is why they proposed to implement a computer vision framework to track and visualize the use of face masks in urban environments. The proposed method uses a convolutional neural network (CNN), an R-CNN Mask detector to detect people, and an Amazon Web Services (AWS) cloud infrastructure for storing and visualizing online data. Resulting in a 96.0% efficiency of face mask detection in public spaces, concluding that the framework accurately tracks the number of people analyzed and detects face masks through the camera implemented in its system.

Aswal et al. (2020) elaborated that the use of the face mask was necessary with the appearance of the pandemic generated by COVID-19 in the city of Wuhan (China) since it protects the essential parts of a person that are the nose and mouth, so the use of this biosecurity measure is highlighted specifically in public places where you interact with various people who we do not know if they are asymptomatic, to all this, add that there are people who have as a security measure in their mobile devices the face unlock in order to manipulate their mobile device in a faster way, that is why they proposed to develop a masked face identification system with a single camera. The proposed method uses YOLOv3 for object detection, YOLO-face for detecting people's faces, and a Retina Face architecture for masked face detection. Obtaining, as a result, an efficiency of 94.5% of detection, concluding that its proposed system manages to establish the facial recognition of the person who uses the face mask with greater precision without violating the security of the mobile device or the user.

Finally, Córdova Eras (2020) identified that at the beginning of the pandemic, there was no effective solution to combat COVID-19 and that in its first stage, it was very devastating, infecting many people and increasing the mortality rate in a surprising way, therefore, the recommendations of the authorities and health organizations that declared mandatory for all people to wear face masks must be followed, maintain two meters of social distance, wash hands frequently, and avoid frequent contact with your mouth or nose. Of all these measures, social distancing is a biosecurity measure that cannot be adequately controlled, which is why the author proposed to implement a social distancing recognition system as a preventive measure against COVID-19 using deep learning. The proposed method consists of using the YOLO version 3 object detection model trained with the COCO image set. Obtaining as a result an accuracy of 80.0%, concluding that the system correctly detects social distancing and that it was also very effective in detecting people with quite high scores in each detection.

3. Methodology

This section will provide the flowchart of the face mask management system approach in Fig. 1 to supply control of medical personnel in the private sector, detailing the internal process that the system performs through the image it obtains from the surveillance camera and then determining whether the person has their face mask. In such a way that, when providing the face mask to the worker, it will be automatically registered so that the administrator can observe and control these supplies.

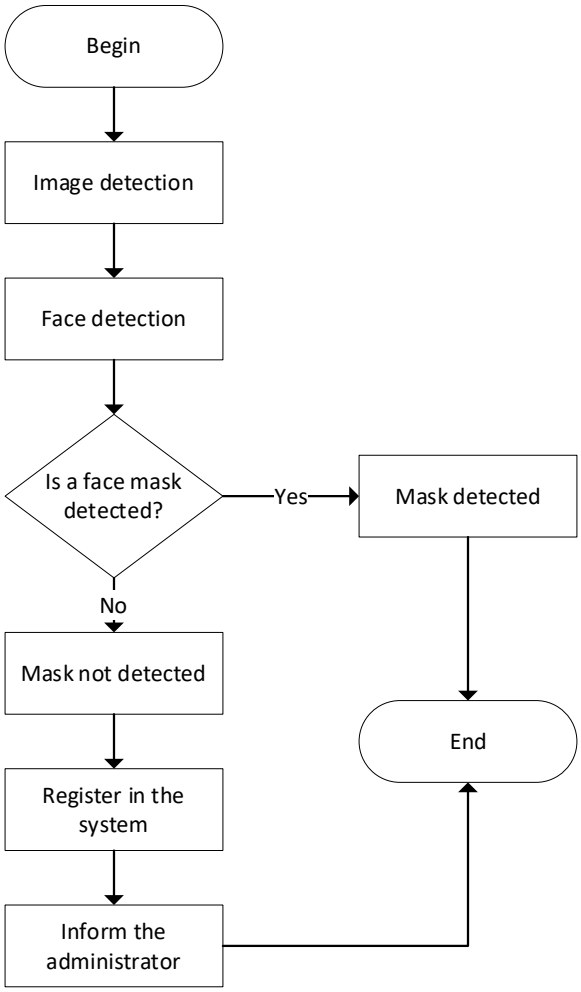

Fig. 1: Facemask management system's flowchart

Next, each process that the system performs will be specified so that it detects the face mask in people and can be visualized by the administrator of the health center.

3.1. Image detection

For the system to detect the images of all medical personnel, it is necessary to use an IP surveillance camera that allows us to obtain the images in real-

time of the people who enter the medical center so that they are sent through the real-time transmission protocol (RTSP) (Liang et al., 2022) to the system and then analyzed. In order for the image to have a good focus of the entire panorama and can have more information about the place, it is necessary that the camera focuses on most of the people who enter the health center, being important that its location is at a height greater than 1.90 meters and not have any obstacle in the focus of the camera so that the system can analyze that information in the best way.

3.2. Face detection

Once the images of the IP camera have been obtained, the system needs to be able to detect the face of people so that it differentiates them from some objects that can be presented or appear in the image. Currently, there are many tools that can be used for facial recognition, but the one that will be used for our proposed system is the Viola-Jones algorithm (Viola and Jones, 2004), which mainly requires images where the faces are located vertically and focused in front of the camera without any occlusion. Viola-Jones algorithm has four stages: the selection of Haar's features, the creation of the integral image to facilitate the calculation of the above characteristics, training using the AdaBoost algorithm, and finally obtaining cascading classifiers (Salazar et al., 2019). It should be noted that these stages of the Viola-Jones algorithm are performed automatically internally, without the need to be configuring it and that is why this tool was used for its ease in its handling and easy adaptation in our proposed system.

3.3. Mask detector

Once the face of the person who is entering the health center has been detected, a frame is generated that is subsequently analyzed to determine whether the person has the face mask on. To do this, a preprocessing is done that consists of four steps that are to change the size of the image for better analysis, convert the image to the matrix to form a better digital image, preprocess the input using MobileNetV2, and finally perform hot encoding to the tags (Sanjaya and Rakhmawan, 2020). The principle of using the MobileNetV2 neural network is that it uses few resources, allowing us to implement it on a Raspberry Pi. When performing the entire process of image analysis, the algorithm will indicate if the person's face has its mask on and highlight it green, if the algorithm detects that the person's face does not have a mask, it will highlight it red.

4. Detection system

In this part, we design the operation of the face mask detector system, as shown in Fig. 2. We try to get people to wear the face mask correctly so that they can enter a medical center, either to make a medical consultation or documentation.

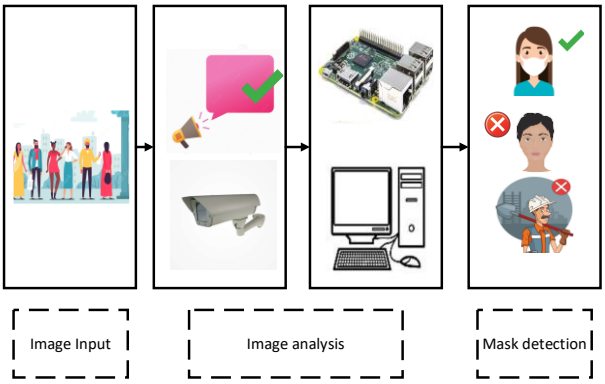

Fig. 2: Face mask detector system

The operation of the system consists of the IP camera, and the entrance door of the medical center is focused in a panoramic way, with this, the people who are about to enter would be observed. Once the IP camera has the corresponding images, this information is sent to a computer so that it can detect the person's face using the Viola-Jones algorithm as a tool and obtain from that analysis a framework that will then be analyzed through a preprocessing carried out by the MobileNetV2 neural network developed in Raspberry Pi so that it can differentiate when a person has or does not have the face mask on.

When the neural network detects that the person has the face mask on, it will show it on the monitor highlighting it in green, otherwise, it will highlight it in red and give a warning through a horn that is located at the entrance door of the health center so that the personnel in charge can provide a face mask and can enter the health center, as well as the system will store the record on each face mask that is provided to the worker so that a report can be developed and be sent to the administrator in charge of controlling the supplies of face masks that are in the health center. All the operation carried out by the system is done automatically, the neural network must be previously trained so that it recognizes quickly if the person has placed his face mask.

5. Results

This article focused on a face mask management system for the supply control of medical personnel in the private sector. With this, the objective of requiring medical personnel to use the face mask in a mandatory manner and avoid the formation of a new source of contagion of COVID-19 is fulfilled since being a closed area the virus can spread quickly. The algorithm used for the development of the facial mask administration system uses various techniques or stages that allow us to detect the face and face mask of medical personnel and manages to differentiate their correct use of the face mask at the time of wanting to enter the health center to obtain better control, as shown in Fig. 3, where the use of this algorithm for our proposed system can analyze

and detect several people simultaneously and show if they use the face mask correctly.

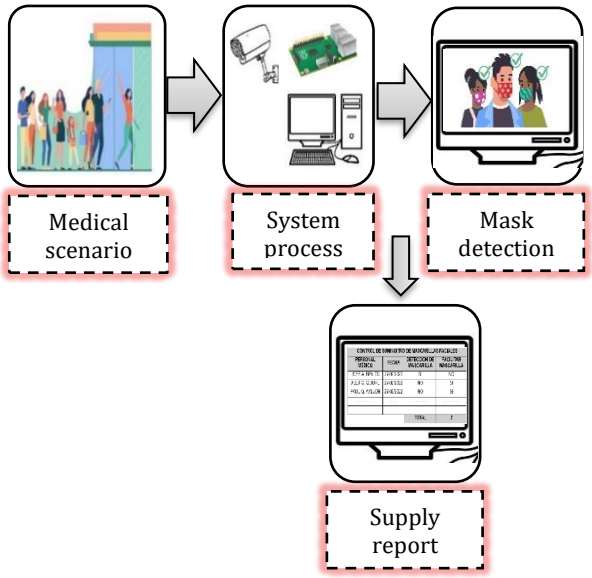

Fig. 3: Face mask administration system

Table 1 shows the characteristics of the face mask administration system for the control of supplies of medical personnel in the private sector. According to the above, the system complies with each parameter that was indicated throughout the paper so that it works in the best way, presenting a percentage of efficiency of 97.12% in detecting the face masks of the medical staff, being very useful to have knowledge about the correct use of the face mask in health centers and if in case the worker forgets his face mask, you will be provided with a mask and automatically registered in the system to control these supplies, with this, the system helps reduce contagion between people.

Table 1: Characteristics of the proposed system

Device	Raspberry Pi 3 Model B
Camera distance	Minimum: 10 centimeters Maximum: 30 meters
Camera height	Greater than 1.90 meters
Mask control	Entrance door
Detection time	3 seconds

The location of the IP camera influences the photo quality obtained for further processing, it should not exceed a distance greater than 30 meters in the focus of people's faces and must also be at a height greater than 1.90 meters so that a sharp and good quality image is obtained so that it is then processed and the detection of people can be shown on the monitor so that it can make a final report that will be sent and viewed by the administrator in charge of controlling the supplies of face masks. For the implementation of the face mask administration system, you must have all the tools that were elaborated throughout the article. These tools were considered because they work in the best way in the analysis and in addition to being low cost, it should be noted that the importance of implementing this system should not present complications for any health center that intends to use it to control the placement of the face mask in all medical personnel. The system can be used not only in a health center but it can also be used in shopping centers, universities, markets, or anywhere where people crowd to enter a public place, with this, the system would respect this important biosecurity measure that has currently been set aside even knowing that this virus spreads quickly, new outbreaks of infections are observed in several countries.

6. Discussion

With the arrival of COVID-19 in various countries, many research works were developed that seek to prevent the spread of the virus. Therefore, this work presents some differences with respect to other research works, for example, the work done by Srinivasan et al. (2021) who proposed to develop a COVID-19 monitoring system that uses social distancing and detection of face masks in surveillance video datasets. From where they obtained a result of 91.2% efficiency, but this proposed system must improve in the part of its people detection module since processing the video takes too long making it take too long to send the information. In the work done by Vinh and Anh (2020), where the authors proposed to develop a real-time face mask detector system that uses the YOLOv3 algorithm and Haar's cascade classifier. Where they obtained a result of 90.1% efficiency, but this proposed system presents complexity in its manipulation so that the personnel in charge would have problems controlling it, in addition to needing prior training to send the recorded data. In the work done by Draughon et al. (2020), where the authors proposed the implementation of a computer vision framework to track and visualize the use of face masks in urban environments. Where they obtained a result of 96.0% efficiency, but the framework proposed by the authors in their system when using the camera does not track people as they move between different fields of vision, limiting the operation of their system. The work done by Aswal et al. (2020), where the authors proposed a masked face identification system with a single camera. Where they obtained a result of 94.5% efficiency, but the YOLOv3 algorithm fails in the appearance changes because this algorithm has been trained with masked faces making it difficult to decide the proposed system. In the work done by Córdova Eras (2020), where the author proposed to develop the implementation of a social distancing recognition system as a preventive measure for COVID-19 using Deep Learning. While it is true, they had a result of 80.0% efficiency, this system proposed by the author cannot detect the temperature change that a person could have when entering a certain place.

7. Conclusion and recommendation

It is concluded that the system works in the best way since it only requires images that are obtained

by a surveillance camera located at the entrance door of the health center to perform the corresponding analysis, being a necessary and important system that can be used to reduce COVID-19 infections within a health center where there are many people waiting to be treated. The face mask administration system is completely safe and reliable since it presents a percentage of efficiency of 97.12% in detecting the face masks of medical personnel. In addition, it does not put at risk the security personnel in charge of the entrance of the health center and enforces and respects this important biosecurity measure established by the government that covers the part of the nose and mouth of the person so that they avoid getting infected. The system performs in the best way the evaluation of all medical personnel to know whether they use the face mask at the time of entry, taking a detection time of 3 seconds for each person that is visualized through the IP camera, being an important system that allows controlling the entry of people. The system performs the evaluation of the medical staff regarding the use of their face mask almost instantaneously, this is because the algorithm has been previously trained with several images and this facilitates the analysis, being able to reliably determine the report that sends to the administrator of the health center. It is concluded that the system can be used in various places where you want to control the entry of people who comply with this biosecurity measure. This means that this system does not present limitations in its use and can be implemented without any difficulty since it uses low-cost tools.

As a future work, a database will be added to our face mask management system so that all the registered reports can be stored in the cloud within a health center, in such a way that it facilitates the administrator to search for previous reports. It is recommended to use the specified tools for the proper functioning of the system, and also the good location of the surveillance camera to avoid inconveniences when the algorithm performs the corresponding analysis.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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