International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 4
DOI: https://doi.org/10.17762/ijritcc.v11i4.6377
***Article Received**: 26 January 2023 **Revised**: 24 February 2023 **Accepted**: 05 March 2023*

Internal Control Automatic Physical Distance Detection System for Patient Care against a Possible COVID-19 Infection within a Health Center

Yrene Uribe-Hernandez[1], Marilu Polo-Nicacio[2], Astrid Cardenas-Solis[3], Alex Pacheco-Pumaleque[4]
[1]Facultad de Ciencias Empresariales
Universidad Nacional de Cañete
Lima, Peru
yuribe@undc.edu.pe
[2]Facultad de Ciencias Empresariales
Universidad Nacional de Cañete
Lima, Peru
mpolo@undc.edu.pe
[3]Facultad de Ciencias Empresariales
Universidad Nacional de Cañete
Lima, Peru
acardenas@undc.edu.pe
[4]Facultad de Ciencias Empresariales
Universidad Nacional de Cañete
Lima, Peru
apacheco@undc.edu.pe

Abstract— Currently, COVID-19 is still present in our environment, affecting various people regardless of age. From its appearance in the city of Wuhan (China), it caused a crisis in the health system due to its rapid transmission of contagion and the lack of medicines to combat this virus, therefore, it was declared a pandemic, due to the high mortality rate that occurred around the world. To combat this viral disease, various biosecurity measures were established such as the mandatory use of a face mask and physical distancing at least 1 meter, with physical distancing being the biosecurity measure that is not respected, worse in closed places such as medical centers where a focus of contagion could originate for various patients. By respecting physical distancing, it would avoid causing a crowd that would cause disorder in the health center, therefore, it is important to maintain distancing to avoid the spread of COVID-19. In view of this problem, in this article an automatic physical distance detection system was carried out for patient care in the face of a possible COVID-19 infection within a health center, enforcing this important biosecurity measure and preventing the spread of COVID-19. Through the development of the proposed system, 98.79% efficiency was obtained in calculating the physical distancing of patients who are inside the health center, taking only 40 seconds to analyze the images of the patients.

Keywords- Centroids, COVID-19, Image processing, Python, Peru, WHO.

I. INTRODUCTION

In the city of Wuhan, China, several cases of pneumonia were identified from a new coronavirus that has different names, according to the World Health Organization (WHO), the virus is called 2019-nCoV, while, according to the International Committee on Taxonomy of Viruses, the virus is called SARS-CoV-2 [1]. This coronavirus disease (COVID-19) is caused by a virus called SARS-CoV-2 that caused at the end of December 2019 a huge problemfor public healtharound the world due to its rapid spread, therefore, the World Health Organization (WHO) declared it a pandemic in March 2020 [2]. Being a new virus, initially the main symptoms were associated with a simple influence, however, the SARS-CoV-2 virus was more dangerous than what was reported early in its appearance in the city of Wuhan. [3]

Being a highly contagious virus, the World Health Organization (WHO) recommended various biosecurity measures to control the transmission of the virus, as well as the suspension of all public activity and mandatory social isolation [4]. In Peru, the first case was reported in the month of March 2020, since then until April of the same year, more than 26,147 infected and more than 685 deaths were reported, with the regions of Lima being the ones that were most harmed with the control of this viral disease [5], crudely revealing the terrible health situation in the country [6] and being until today a viral disease that put in serious difficulties to the world throughout its contemporary history.[7]

The biosecurity measures recommended by the World Health Organization (WHO) are based on the mandatory use of a mask and social distancing that must be maintained at least 1 meter away from others [8], avoiding crowds and direct contact, without distinction of age since the virus affects young people, adults and the elderly, even if they don't seem sick [9]. The risks of contagion of COVID-19 are higher in crowded and insufficiently ventilated spaces in which infected people spend a lot of time together or very close to each other [10], with social distancing being one of the most important prevention measures that can prevent the transmission of the virus, but there is a breach with this biosecurity measure, especially in health centers that are closed spaces and without much ventilation [11], according to a hospital stay, it was evidenced that 61% of patients evaluated do not comply with the physical distancing highlighted by the Ministry of Health (MINSA), 26% indicated that they have no knowledge about the physical distance established by the MINSA, while 13% always consider respecting physical distancing from other patients to prevent contagion [12]. Therefore, it is important to respect the physical distance of at least 1 meter to avoid the spread of COVID-19 [13], since outbreaks of infections continue to be reported in places where there is greater congestion of people in closed spaces.

The objective of this research work is to carry out an automatic physical distance detection system for patient care against a possible COVID-19 infection within a health center to comply with this important biosecurity measure among patients within a closed space such as medical centers, Avoiding the spread of this viral disease in patients by crowding inside a health center when carrying out a procedure or being attended by a doctor. For the elaboration of the system, an IP camera was used to obtain images of the patients analyzed through a static background, located at a height of 4 meters for greater focus, applying the method of moments for the location of centroids and the Euclidean method for evaluating the distance between patients using the Python programming language. Python is a high-level language that has several applications that allow programming in a friendly way and can be understood by any programmer.

In section II, the literature review of some research papers was carried out. In section III, the methodology shall indicate the block diagram of the system, specifying each corresponding stage of the system. In section IV, image processing will be carried out for the detection of patients through the subtraction of funds. In section V, the estimation of the distance between patients will be made. In section VI, the results of the automatic physical distance detection system shall be presented. In section VII, the discussion of the system with other research works will be carried out. Finally, in section VIII, the conclusion and recommendation of the automatic physical distance detection system will be made.

II. LITERATURE REVIEW

COVID-19, being a highly contagious virus, is difficult to determine with the naked eye if a person may be infected and not present any symptoms, hindering the situation of patients who may have some direct contact and unintentionally can be infected with the virus, so it is necessary to prevent contagion by maintaining the corresponding physical distance from other patients, Since they could be asymptomatic patients who are not aware that they are infected and can continue to spread the virus directly, for this, automatic systems can be used that can determine physical distancing. For example: In [14], the authors mention that the COVID-19 disease, being so infectious, has created a health crisis for people in the world, to prevent further infections, one of the measures that has proven to be key in a complicated situation that is experienced around the world has been applied, is physical distancing an efficient measure capable of slowing the spread of COVID-19 among people in closed or crowded spaces, which is why they proposed to develop a real-time people detection system for monitoring physical distancing in the COVID-19 pandemic. The proposed method consists of developing a human detection network using PeleeNet, which allows to improve the characteristics of small objects, facilitating the detection of people through human heads by applying various functions of multiple scales and spatial attention, as well as an unmanned aerial vehicle that will allow the approach of people to monitor physical distancing remotely with a flexible platform. Obtaining as a result an efficiency of 92.22% average accuracy at about 76 frames per second, concluding that the development of its system reliably achieves the monitoring of physical distancing between individuals without any inconvenience.

In [15], the authors mention that the appearance of COVID-19 undoubtedly affected all countries by spreading through direct interaction between people, especially in closed spaces due to lack of ventilation, therefore, one of the prevention measures for the transmission of COVID-19 is physical distancing, however, it is not respected by all people and that is why movements and interactions must be monitored. between people in enclosed spaces and giving warnings, which is why they proposed to develop a physical distancing surveillance system through a smart drone using YOLO in a robot operating system simulation environment. The proposed method consists of developing a system capable of locating, detecting, identifying closed spaces and warning about physical distancing using YOLO-v3 for the detections of people and defining a value of physical distance through the drone with the simulation Robot Operating System and Gazebo with an implementation of roads.

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Obtaining as a result an efficiency of 90% of crowd detection, concluding that the operation of its system works easily and helps with the detection of physical distance between people.

In [16], the authors mention that the COVID-19 pandemic has led to the exploration of various techniques to reduce the spread of the virus, with physical distancing between people being an effective measure, which has been applied by various countries and has generated a positive result by reducing the number of contagion that today continues to increase due to lack of compliance in public places such as supermarkets, hospitals, etc., where more people are concentrated and do not maintain distance from other people, that is why they proposed to develop a portable physical distance detection system in public spaces. The proposed method consists of using an ultrasonic sensor for distance detection, a STM32F446 microcontroller whose function is to read the value of the sensor and calculate the distance between both people to remind them if the distance is less than the established value, likewise, this microcontroller is compatible with various electronic devices due to its high execution speed, They also used a buzzer so that it can emit sound whenever the established distance between people is not met, being able to visualize through an LCD module. Obtaining as a result an efficiency of 91.01%, concluding that its system establishes physical distance correctly, preventing people from crowding in an enclosed space.

In [17], the authors mention that people currently do not respect physical distancing from others, which is why physical distancing must be monitored by applying IoT, which when integrated into a traditional communication network could solve this daily problem that to date continues to affect people and increasing the level of contagion, that is why applying this biosecurity measure could reduce COVID-19 infections to provide greater security to people against this pandemic, which is why they proposed to develop a COVID-19 physical distancing detector system using the Internet of Things. The proposed method consists of developing a physical distance detector system that generates an alert when physical distancing is not in the established measure, using a Tinker cad IoT Simulation software that is based on an Arduino simulation to make circuits using soft logic to simulate and assemble, likewise, an Arduino UNO was used together with an ultrasonic sensor, a breadboard and a buzzer for the emission of sound to the user. Obtaining as a result an efficiency of 89.36%, concluding that its system is optimal in terms of time and cost, because it uses free code technological tools, allowing the manipulation of the system to be free and easy.

In [18], the authors mention that to avoid the spread of COVID-19, vaccination is not enough, but also various preventive measures must be taken such as physical distancing and frequent hand washing, although physical distancing is not respected by people in public places, so maintaining physical distance between people is important to be able to face this virus that is currently affecting our environment to people regardless of age, which is why they proposed to develop an automatic physical distancing system to minimize COVID-19 infection. The proposed method consists of using an infrared sensor for the detection of people, a servo motor that will allow the person to pass if they are in the corresponding location, they also used a liquid crystal display module (LCD) to visualize the number of people in the queue, as well as an alert generator to alert people if they are respecting the established physical distancing. Obtaining as a result an efficiency of 93.41%, concluding that the system presents important characteristics to calculate the physical distance between people, in addition to being a low-cost system.

III. METHODOLOGY

In this part, the block diagram of the automatic physical distance detection system for patient care against a possible COVID-19 infection within a health center was made, as shown in figure 1, detailing each corresponding stage of the system so that it calculates the distance between people accurately and safely.

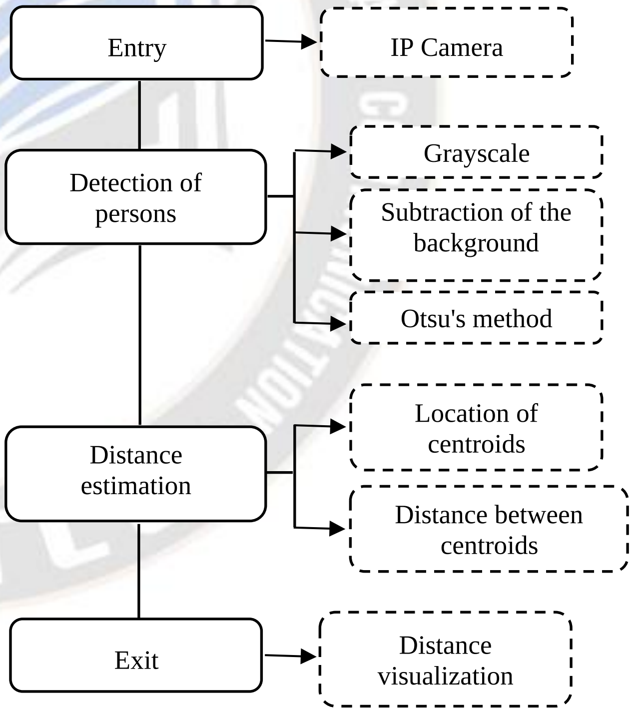

Figure 1. System block diagram

According to Figure 1, the distance detection system is based on a series of stages that will be described below so that physical distancing between people within a health facility can be determined.

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A. Entry Stage

At this stage, the images acquired by the IP camera are entered into the system with a 4K image resolution, which allows patients to be monitored using software that connects directly to the internet that, unlike a webcam, does not need a computer to transmit the video images. It should be noted that the camera must be located at a height of 4 meters above ground level, this is important because it is intended to obtain images with wide panoramas of patients so that the system can analyze the physical distance of people who are inside the health center. It is important that the IP camera has line of sight, that is, that there is no obstacle that stands in the way of the IP camera lens so that it can obtain the corresponding images.

B. People detection stage

At this stage, it is intended to detect people who are located within the health center through the technique of grayscale, background subtraction and the Otsu method. Through the application of these techniques, an improvement in the threshold values can be obtained before the possible variation of luminosity of the pixels at the time of obtaining the images through the IP camera. By using these image processing techniques, the moving person can be separated from the background of the image, thus detecting people inside the health center.

C. Distance estimation stage

In this stage, the mathematical part that is applied once the algorithm manages to detect people within the image to know the point where they are through the location of centroids is highlighted, this will allow to know the location of people through coordinates.

After finding the coordinate points, the Euclidean method is applied to know the estimated distance between people, so the system would calculate the distance by means of the coordinate points in which people are located.

D. Departure stage

At this stage, the system has already made all the corresponding calculation to show the value of the physical distance in which people are inside the health center. With this, it is already possible to know if people respect this important biosecurity measure that helps prevent the spread of COVID-19 between people in an enclosed space.

IV. IMAGE PROCESSING FORSCREEN DETECTION

For the detection of people, you have to perform the processing of images to the image obtained by means of the IP camera, for this you have to use image processing techniques such as grayscale, background subtraction and with the Otsu method change the similarity between the objects to be extracted and the background, obtaining a clear difference between the two. Image processing techniques are used by means of Python, which is why the RGB image collected from the IP camera must be declared.

A. Grayscale

The grayscale technique or RGB2GRAY, is the first step for the processing of the image converting it from RGB (Red, Green, Blue) to grayscales, changing the intensity of each color in values between 0 (black) and 255 (white), existing different shades of gray in an 8-bit image in two dimensions, To do this, you need to use some commands shown below:

```
def escala_de_grises (IM):
    add = ("C:/Users/image_gris/pictures/" + im)
    im = Image.open(add)
    im.show()
    im2 = im
    i = 0
    while i < im2.size[0]:
        j = 0
        while j < im2.size[1]:
            r, g, b = im2.getpixel((i,j))
            g = (r + g + b) / 3
            grey = int(g)
            pixel = tuple ([gray, gray, gray])
            im2.putpixel((i,j), pixel)
            j+=1
        i+=1
    im2.show()
```

Also, grayscale is a scale used in digital images where the value of each pixel has a value equivalent to a shade of gray. The images depicted of this type are composed of shades of gray, as shown in Figure 2.

Figure 2. Grayscale image

B. Bottom subtraction

The technique of background subtraction is the second step of image processing to detect moving objects, being an important step that allows to discard the rest of the image scene because it will remain without movement. Likewise, this technique performs the subtraction between the frame of the

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image and the background, obtaining as a result the person present in the mobile foreground of the static background [19], for this, it is necessary to use some commands shown below:

```
Import CV2
cap = cv2. VideoCapture('vtest.avi')
fgbg = cv2.bgsegm.createBackgroundSubtractorMOG()
while True:
        ret, frame = cap.read()
        if ret == False: break
        fgmask = fgbg.apply(frame)
        cv2.imshow('fgmask',fgmask)
        cv2.imshow('frame',frame)
        k = cv2.waitKey(30) & 0xFF
        if k == 27:
              break
cap.release()
cv2.destroyAllWindows()
```

Likewise, the background subtraction used in the digital image will analyze the image using a static camera that captures the entire scene, as shown in figure 3.

Figure 3. Image with background subtraction

C. Otsu method

Otsu's method technique is the third step of image processing to achieve a noticeable difference between the extracted objects with respect to the background of the scene. Likewise, the Otsu method allows you to choose the optimal threshold to maximize the variance between the classes by searching, which unlike simple thresholding, this method performs the calculation of the threshold automatically for the entire image, maintaining the same threshold throughout the image without variations. Similarly, the Otsu method requires more time to select a threshold with an adequate multilevel when the number of classes in the image increases. Thresholding creates binary images from a grayscale image, setting all pixels below the threshold to zero and all pixels above threshold to one [20]. In addition, the algorithm of the Otsu method performs the calculation of the threshold value automatically, using some commands shown below:

```
# Thresholding by Otsu
     ret2,th2=cv2.threshold(img,0,255,cv2. THRESH_BINARY+cv2.
     THRESH_OTSU)
     cv2.imshow('Threshold Otsu', th2)
     k = cv2.waitKey()
# Otsu thresholding
     blur = cv2. GaussianBlur(img,(5,5),0)
     ret3,th3=cv2.threshold(blur,0,255,cv2. THRESH_BINARY+cv2.
     THRESH_OTSU)
     cv2.imshow('Umbralizacion Otsu Gaussiano', th3)
     k = cv2.waitKey()
     cv2.destroyAllWindows()
```

V. ESTIMATING THE DISTANCE BETWEEN PATIENTS

Once the image processing has been carried out to distinguish the people from the background of the scene obtained by the IP camera, we continue with the location of the centroids of each person found in the scene to determine the corresponding distance between them.

A. Location of centroids

Using the centroid location technique, the image is processed to find the central point of an area through the intersection of medians. However, the irregularly shaped central point is not so obvious and requires a more complicated calculation, which is why the location of the centroids requires defined mathematical calculations to indicate the center of mass as a given point.

The way to calculate the centroid involves taking the average distance in each direction and expressing it as a proportion of the total area of the shape, where each point at which the shape varies in size is known as momentum. Likewise, complex shapes require more moments to find the centroid and computers can perform this measurement frequency more accurately and quickly [21].

B. Distance between centroids

Once the point of the centroids for each person is calculated, another calculation is made to determine the Euclidean distance between the points of the centroids. With this, the value of the distance in which each person is with respect to the others would already be known.

The Euclidean distance is based on the calculation of the distance between two points, in this case it would be the separation between two pixels because we are analyzing an image in a two-dimensional plane, describing the relationship of each pixel with an origin or a set of origins based on the straight-line distance using the following formula shown below [22]:

$$d(P,Q) = \sqrt{(X_Q - X_P)^2 + (Y_Q - Y_P)^2}$$

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Where P and Q are the points in the Cartesian plane, while (X, Y) are the coordinates of the points in the two-dimensional plane of the captured image. With this equation you can calculate the distance between people who are in the same scene.

VI. RESULTS

With the development of the automatic physical distance detection system for patient care, the objective of enforcing the corresponding distance between patients within a health center is met by applying image processing techniques for fast and accurate analysis, avoiding the spread of this virus that currently continues to affect people due to its rapid transmission of contagion.

According to the corresponding analysis of the system, a set of 15 images of patients who were inside the health center was obtained to determine the physical distance, being efficient in the part of the calculation of the distance, likewise, it was observed that the system could know the physical distance of several people simultaneously through the IP camera. Table I shows the characteristics of the distance detector system.

TABLE I. SYSTEM CHARACTERISTICS

Distance detection system	
Power supply:	220v AC
Height IP Camera:	4 m
Focal length camera:	Normal: 0 - 30 mm Maximum: 45 - 110 mm
Analysis of patients:	Full body
Detection Location:	Entrance door
Analysis time:	40 seconds
Accuracy:	98,79%

According to table I, the focal length will depend on the model of the IP camera used for the health center, it is advisable that it does not exceed the range specified above so that the camera has a good angle of view. Likewise, the system can analyze the complete shape of the patients to determine the corresponding distance, as shown in Figure 4.

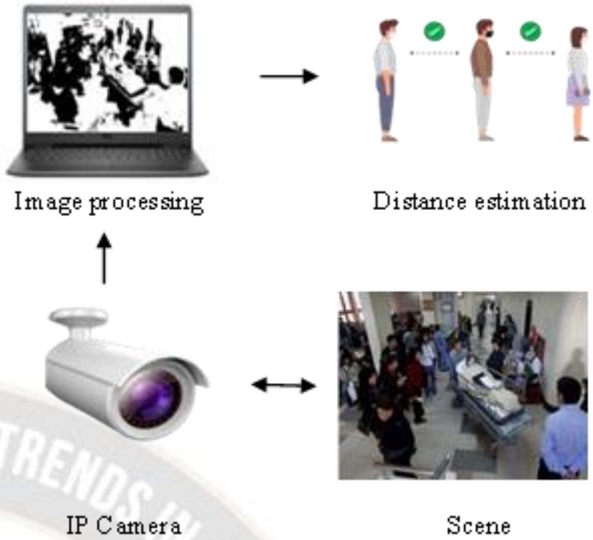

Figure 4. Distance sensing system

According to Figure 4, the camera's focus on patients has a broad picture and without any obstacles that prevent the correct focus of patients. Once the camera obtains the images, image processing is performed in Python applying the techniques mentioned above to be able to determine the physical distance that has at least 1 meter. It should be noted that, if patients do not respect the corresponding physical distancing, a health center worker must alert patients to respect distancing and prevent the spread of COVID-19.

With the development of this system, there will be an important tool that would help reduce the number of infections of patients with COVID-19 that takes 40 seconds to analyze the images of patients to determine physical distancing. Likewise, this system can be implemented in places where there is a lot of agglomeration of people such as supermarkets or public establishments to fortify this important biosecurity measure.

The values obtained by the system are efficient, being able to be implemented in any health center to reinforce physical distancing safely. Its operation is mainly due to the program made in Python that allowed us to analyze the image of patients within the health center, which is why the characteristics specified above must be respected so that the system works correctly with an efficiency of 98.79%, being fundamental because the virus has not disappeared and there are still outbreaks of infections in different parts of the country for not respecting physical distancing, as well as not using the face mask.

VII. DISCUSSION

There is currently a concern on the part of the health system because of the outbreaks of COVID-19 contagion that our society is facing, thinking that the virus has already disappeared from our environment is a misconception that has caused people to neglect themselves without respecting the physical distancing that has generated greater infections, therefore, Several research works related to physical distancing have been developed that try to provide information about the distance between people to avoid contagion.

Likewise, this system complies in determining the physical distance between patients within an enclosed space such as medical centers, helping to prevent the spread of this viral disease. On the other hand, this system presents differences with other research works developed, for example, the work carried out by , [14]where the authors proposed to develop a real-time people detection system for the monitoring of physical distancing in the COVID-19 pandemic. Where they obtained a result of 92.22% efficiency, but this system when working with a detection network does not include security in its system, making it vulnerable to any user when entering false information.

We also have the work developed by , where the authors proposed to develop a physical distancing surveillance system through an intelligent drone using YOLO in a robot operating system simulation environment. Where they obtained a result of 90% efficiency, but this system has not been tested in real environments, only a simulation was developed to test the operation of their system, so their results are not reliable in the calculation of physical distance. [15]

We also have the work developed by , where the authors proposed to develop a portable physical distance detection system in public spaces. Where they obtained a result of 91.01% efficiency, but this system is not interactive with the user since it does not instantly alert the physical distance between both people, likewise, the buzzer in a public space will not be heard by the user due to the excessive noise that exists in those places, so this system is not reliable for users. [16]

We also have the work developed by , where the authors proposed to develop a COVID-19 physical distancing detector system using the Internet of Things. Where they obtained a result of 89.36% efficiency, but this system is limited in operation within a mobile device because it has not developed a mobile application that allows it to alert the user about the physical distance from other people, as well as the few times that its system that generates insecurity has been tested.[17]

We also have the work developed by , where the authors proposed to develop an automatic physical distancing system to minimize COVID-19 infection. Where they obtained a result of 93.41% efficiency, but this system uses an infrared sensor that can present interference with some external elements, specifically with ambient lighting, this makes the calculation of physical distancing may vary with respect to the established value, making it an unreliable system. Below, table I [18]I is shown where the comparison of this system (a) with our proposed system (b) is made.

TABLE II. COMPARISON OF DETECTION SYSTEMS

	a	b
System	Manual	Automatic
Information acquisition	Infrared Sensor	IP Camera
Image processing	No	Python
Detection Location	Entrance door	Entrance door
Analysis time	1 minute	40 seconds
Accuracy	93,41%	98,79%

VIII. CONCLUSION AND RECOMMENDATION

It is concluded that the operation of the system is safe and efficient, it calculates the value of the physical distance between patients who are located within the health center quickly. Therefore, this system enforces this important biosecurity measure, helping to prevent COVID-19 infections that continue to affect people of any age.

It is concluded that the proposed system does not put the health personnel in charge of handling it at risk of contagion of COVID-19, since it does not require any physical contactor, it only requires images obtained by the IP camera to perform the image processing through Python programming and obtain the value of the corresponding distance.

It is concluded that the system performs the calculation of the distance value automatically, does not require any manual process, only requires a supervisor who is responsible for giving notice to patients so that they can comply with the physical distance and order can be maintained within the health center and avoid crowds.

It is concluded that the implementation of this system in places where it is intended to control the physical distance between people is viable, especially in closed places with little ventilation, which is why its operation has no limitation and is developed in the best way.

It is concluded that the system performs the calculation of physical distance instantaneously, taking 40 seconds to be able to perform the analysis of the images, contributing in the field of health to avoid COVID-19 infections by maintaining the corresponding order among patients. Likewise, the characteristics specified in the system above must be respected.

As future work, a mobile application will be added to the distance detector system so that the supervisor in charge of maintaining order with respect to physical distance, can have knowledge of the distance of patients through his mobile device and it will be easier for him to make patients respect physical distancing.

It is recommended that when implementing the proposed system, all the specified characteristics are taken into account, as well as the type of camera that will be used that should be static, with an adequate height to have images with wide panoramas so that it can be developed in the best way, without any problem.

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