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Smarat tag for social distance and face mask detection

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***Abstract*---**Today the biggest problem the world is facing above all the natural disasters is the Covid-19. It's been more than a year but the solution to the issue is still at a far fetch. However, still have few ways to control the outbreak as instructed by the WHO (World Health Organization). A few among them are wearing a mask and maintaining social distance. The objective of the project is to detect face masks in a public gathering or an event. The algorithm used in the project to achieve the objective is MobileNet V2. An image of a few people wearing a mask and without wearing a mask is used as an input dataset. There are few processes involved in achieving the objective of the project that include pre-processing, data augmentation, training, testing and image segmentation. After the processes, with the help of the Mask R-CNN algorithm, will get a segmented image of the input dataset of people wearing a mask and people not wearing a mask. Then, the model is implemented using a webcam where get result of people wearing a mask and not wearing a mask along with the accuracy in percentage. In this project, developing a model that can detect people who are not wearing masks in public places. This project

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can be merged with real time applications at airports, railway stations, workplaces, schools, and other public places to ensure compliance with the guidelines for public safety. In the middle of the Covid-19 crisis the project focuses on achieving the guidelines provided by WHO to control the spread of Covid-19.

***Keywords*--**social distance, localization, monitoring, COVID-19.

Introduction

COVID-19 belongs to a big family of viruses that normally causes moderate to mild upper-respiratory tract ailments. It was first reported in Wuhan, China, at the end of December 2020. The World Health Organization (WHO) has declared COVID-19 as a pandemic, and a global coordinated effort is required to stop the spread of the virus. The transmission of COVID-19 remains unclear, though evidence from other viruses indicates that the disease may spread through direct or indirect contact with an infected person. During the ongoing COVID-19 disaster, the Internet of Thing (IoT) has played a significant role in a diverse range of healthcare applications. In general, IoT networks consist of a number of small-size, low-cost, and low-power consumption devices that can be attached to any person or be embedded in any object. Social distancing is critical for people who are at a higher risk for severe illness from COVID-19. Social distancing is the maintenance of a safe distance of at least 1 m from other people in indoor and outdoor spaces to minimize the spread of the virus. It also limits close contact with others in outdoor and indoor spaces, as people can spread the virus before they know that they are sick [1]. Recently, social distancing was proven to be an effective practice to minimize the spreading of COVID-19. Therefore, social distancing has prompted researchers and developers to find technological solutions in order to fight against the spread of the COVID-19 virus. Several mobile applications and IoT devices have been developed recently to work against the spread of COVID-19.

Due to the nature of the virus and the high spread rate, either indoor or outdoor, when human contact exceeds the predefined social distance space, this work presents a system that will assure and monitor the social distance between individuals during runtime with an accuracy of 98% using a smart localization system. The proposed system has been evaluated through several experimental studies. This experiment followed a number of steps, including the technological aspect of building the system (hardware and software), starting with face detection techniques, then gathering and sending information to access points to alert for crowing in the specific area, which include a number of functions to evaluate the spaces and identify whether this obstacle is a person or something else.

Literature Review

Nowadays, Convolutional Neural Networks (CNN) are used in many ways to facilitate humans and also prevent their lives from damages such as fire disasters [15,16], facial feature analysis [17,18], healthcare [19–21], and many others fields

[22–24]; in addition, in several studies, a resource-constrained device has been used to interact in real-time for human lives facilitation [25,26]. In this work, our main focus is on face mask detection for COVID-19 prevention using a CNN. Generally, in most related publications, the focus is on face recognition and construction when wearing face masks. By contrast, this research focuses on the detection of those individuals who are not wearing face masks in public places to help in reducing the transmission of COVID-19. Scientists and researchers have proved that wearing face masks in public places significantly reduces the spreading rate of COVID-19. Bosheng Qin et al. [27] proposed a new method to detect the face mask wearing condition. Their trained model can classify the face mask condition into incorrect, correct, and no face mask wearing conditions. Their trained model has achieved 98.70% accuracy. Chong Li et al. [28] proposed a YOLOv3-based framework for face detection. They have verified their method by training on the WIDER FACE [29], CelebA [30], and FDDB [31] datasets. Their model has achieved 93.9% accuracy. In [32], Din et al. proposed a GAN-based novel framework that can detect and segment the face mask from the face image and regenerate the face image using a GAN. Their trained model-generated images look like the actual images. Nieto-Rodríguez et al. [33] proposed a framework to detect the special face mask in the medical room. They have used real-time image processing for detecting face masks. The objective of their work is to minimize the false-positive rate. They have achieved a 95% recall and a 5% false-positive rate for the detection of the surgical mask. Muhammad et al. [34] proposed a framework called MRGAN to segment the microphone from the face image and used the GAN to reconstruct the segmented holes into the face image. They have trained their model on their synthetic dataset. The trained model works better than the state-of-the-art methods.

Mingijie Jiang et al. [35] proposed a face mask detector called RetinaFaceMask. Their method used a novel object-removal algorithm to remove predictions with low confidence. They have achieved 1.5% and 2.3% higher precision and 5.9% and 11.0% higher recall than state-of-the-art results on face mask and face detection, respectively. On the other hand, they also explored the performance of the proposed method on light-weight neural networks such as MobileNet. Shashi Yadav et al. [36] proposed deep learning mixed with a geometric-based technique to monitor social distancing and face masks in public areas. They have implemented their model on Raspberry pi4. Their model detects violations of social distancing and face mask wearing by receiving input from cameras. When a violation occurs in a specific area, the developed system sends alerts to the control room and notifies the public by an alarm. The paper presented in [37] used a transfer learning strategy for the automatic identification of persons who are not wearing a face mask. In this approach, the researchers used pre-trained InceptionV3 with fine-tuning. They used Simulated Masked Face Dataset (SMFD) for training and testing and also used image augmentation methods to increase the number of training samples for better results evaluation.

Related Works

Many digital tools are being explored and developed to contain the spread of COVID19. In this section, we discuss the existing social distance monitoring and alerting systems. The existing solutions can be categorized into two categories, as presented (Figure 1): wearable social distance systems and standalone social monitoring systems. The former requires attaching a tag to a person (user) to estimate the distance to the surrounding people. In contrast, the latter is based on stationary or mobile devices employed to monitor the social distances between people in the area of interest, based on image analysis methods.

The coronavirus disease 2019 (COVID-19) epidemic has arisen as a major menace all around the world. As the number of cases is gradually increasing day by day, the government has several difficulties in controlling the pandemic situation. The communication of this disease can only be lessened with the proper collaboration of people. Physical distancing, repeated hand sanitizing, and face masking have proven to be quite efficient to control the spreading of the virus, but everyone is not obeying the guidelines. Various technologies like machine learning (ML) algorithms [1], artificial intelligence (AI) approaches [1], Internet of things (IoT) [2–5], and unmanned aerial vehicles (UAV) [6] give a real-time scenario at any given point about (i) the number of people following physical distancing and (ii) whether people are wearing masks or not.

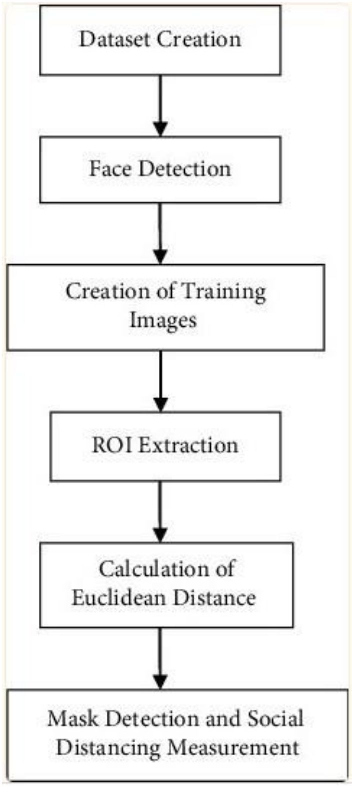
Recently, the rapid transmission of Coronavirus 2019 (COVID-19) is causing a significant health crisis worldwide. The World Health Organization (WHO) issued several guidelines for protection against the spreading of COVID-19. According to the WHO, the most effective preventive measure against COVID-19 is wearing a mask in public and crowded areas. It is quite difficult to manually monitor and determine people with masks and no masks. In this paper, different deep learning architectures were used for better results evaluations. After extensive experimentation, we selected a custom model having the best performance to identify whether people wear a face mask or not and allowing an easy deployment on a small device such as a Jetson Nano. The experimental evaluation is performed on the custom dataset that is developed from the website (See data collection section) after applying different masks on those images. The proposed model in comparison with other methods produced higher accuracy (99% for training accuracy and 99% for validation accuracy). Moreover, the proposed method can be deployed on resource-constrained devices.

The proposed system model

In this system, a model is suggested that uses the combination of OpenCV library with Raspberry Pi to build an Industrial Internet of Things (IIoT) application for mask detection and UAV application for social distance monitoring. The proposed system can identify or verify a person from a video frame. To see the masked face in a frame, first, we need to identify whether the facemask is present or not. If it is present, then it is marked as the region of interest (ROI) followed by its removal and processing for facial mask detection. The faster R-CNN algorithm for facemask detection works very well if the database contains clear images of persons. The employment of the OpenCV library tool proves to be very effective for mask detection and recognition.

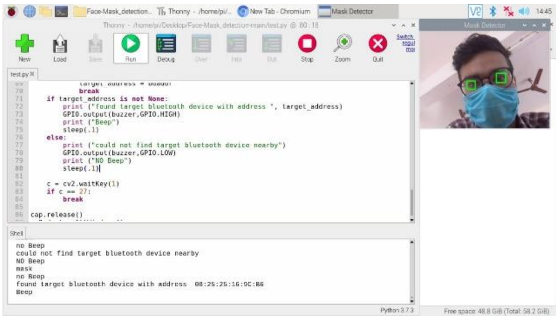
In this research, firstly a deep convolutional neural network (CNN) is employed on a given image to produce feature maps that are given to the training classifier. The region proposal network uses two convolutional layers to identify the region.

After that, ROI pooling is employed to collect and resize the feature maps in order to produce the new feature map.

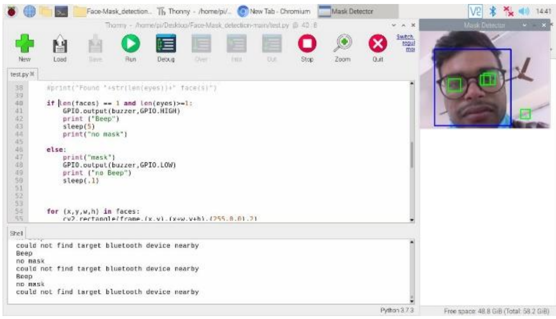


Results

The simulation is performed for 18000 training images collected in the various situations. The validation of the trained model is done against the testing set of 8811 images obtained after simulation on PyTorch. The various parameters such as validation loss, validation accuracy, precision, recall, and F1-score are also calculated in this section. The comparison of the proposed technique for the various situations is also done with other existing state-of-the-art techniques applied on the same image set. Finally, the results for unmask/mask faces, social distancing, and count of persons with real-time video streaming are also presented.



With face mask



Without face mask

Social Distance Monitoring Approach

This section discusses the design and implementation of a new social distance monitoring system based on social distance tags designed to warn users when approaching people are getting too close in common areas. This section discusses the architecture of the proposed system, including the hardware and software components. The developed solution is based on two main approaches: human identification and distance measurements. The human identification function is employed to detect the presence of humans approaching the user (who carries the SD-Tag). In contrast, the distance measurement function estimates the distance between the detected people and the user. The overall concept of the proposed social distancing system is shown in Figure 2. The developed social distance monitoring system consists of four main modules (see Figure 3): human detection, social distance estimation, broadcast, and base-station processing modules.

Human Detection Module

The developed social distance tag (SD-Tag) should be attached to users in public areas (indoor or outdoor) so as to guarantee maintaining social distancing between people in the area of interest. The SD-Tag applies face and eye detection methods to detect the presence of human(s) surrounding the SD-Tag's user. The human detection function is processed by determining the faces or eyes in the surrounding area. This is because most of the women in the Kingdom of Saudi Arabia wear a "Naqab", which shields their faces and, consequently, the face detection method fails to detect the presence of humans.

The Haar cascade classifier is implemented for the face detection method, which is an effective method for object detection, as noted by Viola and Jones [23]. Haar cascade is a machine learning-based approach where many positive and negative images are used to train the Haar cascade classifier. In general, the Haar cascade classifier consists of the following:

- Positive Images: These images include the objects the Haar cascade classifier must identify (faces and eyes in our case).
- Negative Images: These images include everything else that does not contain the objects that need to be identified.

On the other hand, the eye aspect ratio (EAR) function has been adopted to compute the ratio of distances between vertical and horizontal eye landmarks [24]. The value from the EAR function will be approximately constant when the eye is open, and decreases towards a zero value during blinking. Algorithm 1 presents the pseudo code for the person detection system.

Social Distance Estimation Module

In the second stage, the distance to the detected person is estimated using a rangefinder sensor, which can measure the distance between the user (who carries the SD-Tag) and the facing human(s) detected in the first stage. As soon as the SD-Tag obtains a short distance (less than one meter), the SD-Tag will emit warning alerts depending on the distance of the heading person(s) and the number of heading person(s). Algorithm 2 presents the distance estimation algorithm employed in the SD-Tag, and Figure 5 shows the flowchart for the social distance monitoring system.

Conclusion

The spread of Covid-19 is increasing every day in every corner of the world. This needs to be controlled to get back to our normal lives. While the specialists take care of the vaccine part, can help them by following the guidelines provided by WHO to remove/control the spread of this virus. The objective of the project is to recognize people wearing and not wearing masks using MobilenetV2. This algorithm is to convert an input image of a crowded place into our expected output which is identifying people not wearing a mask. Finally evaluating the numerical results.

With the help of this project implemented in proper circumstances can help detect people not wearing masks. This could help health and sanitary officials to implement the WHO guidelines in a much better way. This project is tested in a webcam using the above discussed methods and the results are as expected. With wide use of this project in public gatherings and crowded localities, it will be easier to detect people violating the use of masks.

Future Work

In this project, used MobilenetV2 algorithm and other deep learning techniques to identify people not wearing a mask. Tested this scenario using a webcam and an input dataset. In the future, this project can be used along with other AI methodologies and can be implemented in devices like Raspberry Pi, Autonomous drone systems etc., to improve the efficiency and reduce the detection time taken to detect people not wearing a mask.

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