INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact Factor: 6.078
(Volume 7, Issue 4 - V7I4-1137)
Available online at: https://www.ijariit.com

Face mask detection system

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ABSTRACT

Face masks have become an increasingly important part of human lifestyle. Ever since the pandemic began, people have been encouraged to wear face masks to curb the spread of Covid-19. The aim of this project is to replicate on a computer what human beings are able to do so effortlessly - detect the presence of faces in their field of vision. This project aims at using a camera placed in different places around the area, to capture images and detect the presence of a facemask in real-time. The proposed Face Detection System is an application that automates the detection of frontal human face in a given image. Existence of a mask is indicated by a green square around the person's face along with the percentage of accuracy of the positioning of the mask. Absence of the mask however, is indicated by a red square around the person's face and its related percentage is also displayed to be accurately used for detecting whether a person is wearing mask properly or not.

Keywords— *Face Recognition, Face Localisation, Tensorflow, Normalisation, Real-Time Monitoring*

1. INTRODUCTION

The spread of COVID-19 is increasingly worrying everyone in the world. This virus can be affected from human to human through airborne droplets. According to the instructions from WHO, to reduce the spread of COVID-19, every person needs to wear face mask, follow social distancing, evade crowded areas and always strengthen the immune system. Therefore, to protect everyone, every person should wear the face mask properly when they go outdoors. However, many selfish people don't wear face mask properly with so many excuses.

As face detection, or any subjects related to face processing, is not offered as a study course in the faculty, this project serves as a good opportunity to study face detection and its existing methodology in depth. In the end, the theoretical knowledge is applied to a practical situation. In this case, it will be to implement a face detection system using the existing methodology. Therefore, this project is taken up purely for educational purposes.

The system is built to detect the presence of human face(s) in a 2-dimensionalstatic image. The system will take as input colour RGB 2-D images in bitmap format.

2. DESCRIPTION OF PROJECT

2.1 Domain Studies

(a) Face is defined as front of a person's head from their forehead to their chin.
(b) Face analysis can be categorized into different areas such as detection, recognition, expression recognition.
(c) Face detection is used to determine whether or not there are any faces in a given image and return the image location of each face.
(d) Face localization aims to determine the image position of a person's face.
(e) Face recognition deals with identifying the identity of a person in an image or a sequence.
(f) Facial expression recognition concerns identifying the effective states such as happy, sad, disgusted, etc of humans.

2.2 Feature Extraction

The first step requires computing the gradient of the input face image in both the x and y directions using 1x3 and 2 3x1 edge detector kernels. The horizontal kernel is applied to the input image to produce a horizontal gradient image and the vertical kernel is applied for producing a gradient image. The order in which the kernels are applied does not matter at all the vertical kernel could be applied first too. We can see an example of the gradient image in Figure 1. As it can be observed in the gradient image, the edges of the face are maintained and can be used for further processing.

Figure 1: Input Image, Vertical Edge image, Horizontal Edge Image, Gradient Magnitude.

The next step in the process is to calculate the histogram of the gradient image. The gradient image will be broken up into a grid where each cell is of size 8x8 pixels. For each cell, a gradient histogram is computed.

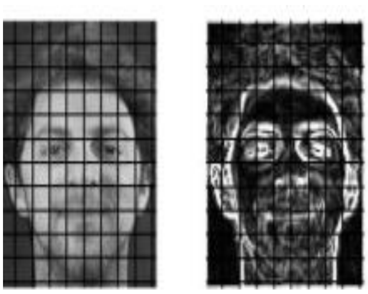


Figure 2. (Left) Input image of face divided into cells. (Right) Gradient image of face divided into cells.

For single cell, the histogram has 9 channels each channel corresponding to a range of directions from 0 to 180 degrees. Each pixel in the corresponding cell will select a channel based on the direction of the gradient and will vote for that channel based on the magnitude of the gradient. The process is repeated for each pixel until the histogram of gradients feature vector is completed. Now we have a HOG feature vector for each cell so the next part of the method is normalization. Normalization is performed on the 36x1 HOG feature vector using the following equation:

$$f = \frac{v}{\sqrt{\|v\|^2 + e}}$$

where v is the 36x1 HOG feature vector, kvk is the norm of v, and e is a small constant. The normalization process is repeated for each block, blocks are moved throughout the image overlapped such that every cell contributes to the HOG feature vectors more than one time. The last step in the feature extraction is to get the HOG feature vector. This is accomplished by concatenating normalized 36x1 feature vectors as given before. So if you have a total of 100 unique block positions which each produce a 36x1 feature vector, the final concatenated HOG feature vector would be length (36)(100) = 3600. Figure below shows an example of a face and its corresponding HOG feature vector.

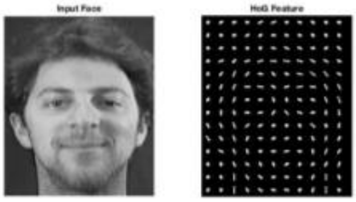


Figure 3: (Left) Input image. (Right) HOG feature of input image

3. SYSTEM REQUIREMENTS

3.1 Hardware Requirements

- Working WebCam
- 4 GB RAM and above
- 1TB Hard disk
- 64-bit processor
- I5 processor
- Operating System
- Power Supply

3.2 Software Requirements

- Python
- OpenCV
- TensorFlow
- MobileNet
- Keras
- Scipy
- Imutils

3.3 Data Sets Used

Without Mask: Consists of hundreds of images of people not wearing a mask as shown in Figure 4.

Figure 4: No mask Dataset.

With Mask: Consists of hundreds of images of people wearing a mask as shown in Figure 5.

Figure 5: With mask Dataset.

4. MODULES

4.1 Functional Requirements

- Accurate face detection
- Accurate mask position
- Perform mathematical computation
- Approximate percentage calculation
- Real-time monitoring
- Display of result

4.2 Non-Functional Requirements

- Scalability
- Accuracy
- Robustness
- Performance
- Reliability
- Response Time
- Maintainability

5. ALGORITHM

Because of its high detection rate and processing speed, the Viola-Jones algorithm is a popular method for facial detection. Feature selection, feature assessment, feature learning to generate a classifier, and cascading classifiers are the four steps of the algorithm. A 2-rectangle feature represents the difference between the sum of the pixels in two adjacent regions of identical shape and size. This idea can be extended to the 3-rectangle and 4-rectangle features. In order to quickly compute these rectangle features, alternate representation of the input image is required, called an integral image. The integral image can be represented by the equation:

$$ii(x,y) = \sum_{x' \leq x, y' \leq y} i(x', y')$$

Where the integral of image is ii(x, y),the original image is i(x, y). The integral image representation can be computed with only one iteration through the entire input image, and allows a sum of a rectangular feature to be computed using only four points.

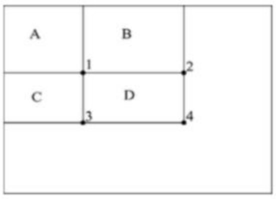


Figure 6: Gird Format Example

2 is equal to the sum of pixels in A and B, 3 is equal to the total of pixels in A and C, and 4 is equal to the sum of pixels in A, B, C, D. With this knowledge, we can determine that the sum of pixels in D is just (4+1) - (2+3). Instead of summing all of the individual pixels in the original image, we can use the integral image and thus reduce the time needed for the feature evaluation part of the algorithm.

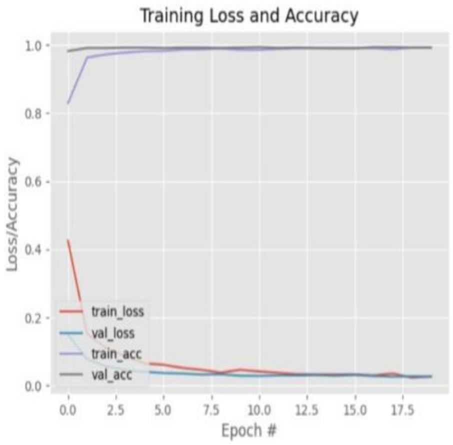
The face identification algorithm's learning section employs Adaboost, which is essentially a linear collection of weak classification functions that produces a strong classifier. The perceptron that provides the least error determines each categorization function. But this is characterized as a weak learner as the classification function does not classify the data well. In order to improve the results, a strong classifier is created after multiple rounds of re-weighing a set weak classification function.

These weights of weak classification functions are inversely proportional to errors. The goal of this stage is to train most relevant features of the face and to disregard any redundant features.

The last step of Viola-Jones algorithm is a cascade of classifiers. The classifiers constructed in the above step form a cascade. In this set up, the goal is to minimize the computation time and achieve a high detection rate. A trade-off exists between the performance in terms of high detection with low false positives and the computation time. However, this also increases computation time. A detector is designed with specific constraints provided by the user which inputs the minimum acceptable detection rate and the maximum acceptable false positive rate. More features and layers are added to it if the detector does not meet the criteria given.

6. GRAPH

The below graph shows the training loss and accuracy obtained during training of the datasets.



7. OUTPUT

The following are the outputs of the facial mask detection system:

Output when there is no mask

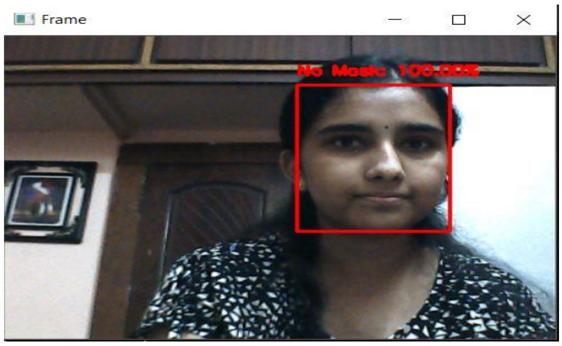


Figure 7: Example 1: Output without mask

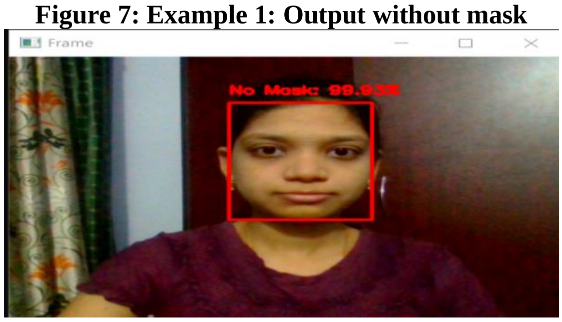


Figure 8: Example 2: Output without mask

Output when wearing a mask

Figure 9: Example 1: Output with mask

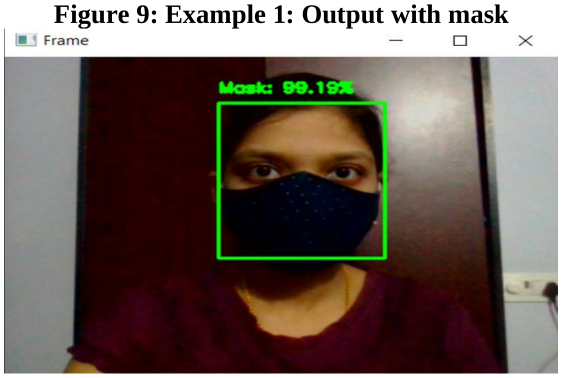


Figure 10: Example 2: Output with mask

8. CONCLUSION
This Face Mask Detection System has been found to be effective in detecting whether people are using masks in public locations, which can harm their own health as well as the health of others in this epidemic. By using CC camera footage as input in public spaces, this can assist government agencies in the detecting process. We were able to achieve a 97 percent overall efficiency**.** The model's precision will be reached, and model optimization will be a continual process, resulting in a very accurate solution. Through this system, we can protect people from virus transmission.

9. FUTURE SCOPE
This project can be further extended in the future to include an exclusive alarm system. The system can implemented to fire an emergency alarm whenever someone not wearing a mask is detected, instead of just showing a red square around them. This would enable security personnel to easily detect those who are not wearing a mask, without the need of continuous surveillance by a human. The person so caught can be seized and appropriate disciplinary action can be taken against him/her.

10. APPLICATIONS
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This type of program would work best for taking first step in face recognition. Also it can be modified slightly to make it fit into certain useful fields

- **Medical Hospitals:** mask detectors can be used to warn doctors or med students to not forget masks
- **Chemical Plants:** mask is a necessity in harmful chemical releasing factories. With the help of this mask detecting system, workers safety will be assured.
- **Drones:** Adding this system upon drones would result in another new useful 360° detection unit that continuously monitors.

11. REFERENCES
It is crucial for a proper and effective method for gathering information to ensure a sound understanding of the system in all aspects. The acquired information will eventually serve as a groundwork for determining the requirements and design of the system.
For the proposed Facial Mask Detection System, the methods used for gathering information are described below:

- **Internet Research:** The internet is a massive repository of data in almost every sector. Because this project is on computer vision and image processing, we did some internet study. It includes conducting research on various facial detection techniques corresponding algorithm, that is published as a journal or a paper. We also acquired some more information from the research papers that are available on the internet**.**
- **Discussion with supervisor:** From time to time, a supervisor consultation session was convened to examine difficulties with the planned system. There is no problem because the Facial Mask Detection System was used for instructional reasons. In the lack of a problem statement, the project's direction must be determined by consulting the supervisor.
- **Books and References:** Referring to books and printed references is also another way of gathering information. The following are the IEEE papers used as reference for Facial Mask Detection Project.

[1] https://ieeexplore.ieee.org/document/8888092
[2] https://ieeexplore.ieee.org/document/9216386
[3] https://ieeexplore.ieee.org/document/9342585
[4] COVID-19 Facemask Detection WITH Deep Learning Aand Computer Vision by Vinitha and Valentina.

