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Detection of Human Faces Covered with disguise and Makeup

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ABSTRACT

Face detection is kind of the identification. When we look at someone's face, we can get information like his or her gender and age. Face detection research has exploded in popularity during the last few decades. Starting with algorithms that can detect faces in constrained environments, today's face detection systems can attain extremely great accuracies at the large scale unconstrained facial datasets. While new algorithms continue to increase performance, the majority of face detection systems are vulnerable to failure when subjected to disguise and cosmetics alterations, which is one of the most difficult covariates to overcome. In this article, the database of disguised and makeup faces (DMFD) is employed. In order to address this issue, we detected the location and size of the facial in the image by using Histogram of Oriented Gradients (HOG) + Linear SVM Machine Learning detector on the Disguise and makeup face database (DMFD).This approach is effective and can detect any disguise and makeup faces in the complex background and illumination variation. The results shows the effectiveness of the face detection system on a database (DMFD) and it provided better results of (99.3%).

MSC. 41A25; 41A35; 41A36

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1. Introduction

The process that detecting faces in an image is known as face detection. The object is to locate each face and draw a rectangle around it.[1] Face detection is a critical first step in tasks including face recognition, face editing, facial attribute classification, and face tracking, and its accuracy has a direct impact on the tasks' effectiveness. Face detection is extremely important in the surveillance and security paradigms. [2,3] Face recognition is a technique for determining a person's identification after they have been detected. On these subjects, extensive research has been conducted. Another major research issue is detecting hidden faces, particularly in high-security areas such as airports or busy areas such as concerts and retail malls, where they may pose a security danger.[4] Also, People should wear masks during the pandemic to assist successfully prevent the transmission of Coronavirus, particularly at the entrances of hospitals and medical facilities. Unmasked people should be warned about by surveillance systems that use face detection approches at medical facilities.[5] Despite significant advancements in uncontrolled face detection in recent decades, reliable and efficient facial detection in wild remains a difficulty and open challenge. Variations in positions, scale, facial expressions, light, face occlusion, disguise, image distortion, and other

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factors all contribute to this. Face detection, unlike generic object detection, has lesser variances in aspect ratio but considerably higher variances in scale (several pixels to thousand pixels).[6] Detecting faces hidden under disguise and makeup is one of the most difficult of this challenges. So far, the majority of disguised face researchers concentrate on face recognition using disguises, with little research on disguised face detection. Disguise is a critical and vital face detection issue. Processing a large volume of data from video surveillance systems in public locations such as ATMs, subways, stadium entrances, and so on has grown extremely challenging in recent years. [7] The goal of our paper is to detect disguised faces from image captured in real environments. Using The Disguise and Makeup Database (DMFD) from (Hong Kong Polytechnic). [8] Its contains (2460 pictures of 410 persons), the majority of which are celebrities (movie/TV stars, sportsmen, politicians) in disguise and/or make-up facial with growth truth (beard, , eye-glasses, mustache, etc) gained under real-world conditions. The key challenge in (DMFD) is detecting face images taken in real-world environments with various covariates such as illumination, occlusion, distance, pose, and change in age. As a result of this, utilizing this database to test the effectiveness of face detection algorithms for (near-range) facial images including disguise and/or make-up as the main covariate is greatly difficult. In this paper designed the face detection system, we detected the location and size of the facial in the image by using Histogram of Oriented Gradients (HOG) + Linear SVM Machine Learning detector on the Disguise and makeup face database (DMFD). Following detecting the face, worked to extracting the face area using face landmarks detection algorithms is the cascade-regression detector to first define face landmarks, and then extracting the facial area without any portion of the background, and face alignment is the final step in the face detection system using facial landmarks and affine transformations. This approach is effective and can detect any disguise and makeup faces in the complex background and illumination variation. All results achieved were tabulated and studied.

2. Literature Survey

Disguise and makeup is a important face detection problem. Our study's purpose is to detect disguised and makeup faces in the DMFD database. Facial detection has been actively studied since its inception in the 1990s, owing to its vast range of practical applications. Processing a huge volume of data from real-world environments has grown extremely complex in recent years. There had been a lot of research done in that field. As an example, Farfade and other in [9] Deep-Dense Face Detector (DDFD) was offered. This method can detected the faces in different orientations using a single model based on deep CNN and does not need landmark annotation. The method is practically as simple as it gets, and it doesn't require any further components like segmentation or (SVM) classifiers.

Li, Haoxiang and other in [10] For the face detection procedure, (CNNC) Convolutional-Neural-Network-Cascade was proposed. initial low resolution phases, the proposed (CNNC) discards background areas and estimates a little number of the diffecultes candidates in the last high resolution phases.The output of each regulation phase is used to adjust the position of the detection window for the next phase's input. The proposed method displays VGA-resolution images at (14) frames per second on a (single core CPU) and achieves the requisite detection performance at (100) frames per second with the use of a GPU.

Kumaar and other in [11] Developed a method for face verification based on the prediction of facial key-points called (DiFRuNNT). It comprises of two neural networks: the first is a convolutional neural network that predicts 20 facial key-points in the image, and the second is a classification neural network that uses the angles and ratios generated from the predicted points to classify the subject. On face identification and verification tasks, prediction of facial keypoints has attained state-of-the-art performance.

Abhila and other in [12] Presented for disguised face detection, the Viola Jones approach was utilized. The algorithm works by looking for particular haar-like characteristics. These characteristics are used to assess whether or not there is a face on the image. This algorithm recognizes a face in an image, whether it is masked or not. The goal of this article is to recognize a disguised face.

Tamgale and other in [13] A Deep CNN architecture was utilized to identify the users attempting a fraudulent-ATM-transaction with a disguised face. Network is trained on a dataset of photos captured in settings similar to those encountered on ATMs. There were three different classifications (Disguised face, Partially Disguised face and Undisguised face). Only with low background clutter on the frames does this method display excellent classification accuracy. In the other situation, there are numerous false positives lurking in the background. some objects on the background that resemble a face or have a shape that resembles a face may be labeled as disguised face.

Al-Jbaar, Mamoon and other in [14] discussed the construction of face recognition using OpenCV and the Dlib package for the security system. For object detection, used the Haar Cascade classifier, and for feature extraction, utilized the LBPH methodology and got an accuracy of about 70%, which isn't ideal because the algorithms that using have certain flaws in terms of face orientation and rotation. Although the LBPH algorithm is used to lessen the effect of light fluctuations, it is not ideal. As a result of these factors, as well as the low accuracy, decided to switch to the neural network (dlib library) in order to achieve better results. used the (OpenFace) library in the neural networks, which is a deep learning facial recognition model that is fully built-in in Python. This technology can be tweaked to influence the environment around you based on your facial features (IoT applications).

Li, Chong and other in [15] Only for face detection, the author of this study employed YOLOv3 with DarkNet-53 as a backbone for detection. With training on Large-scale CelebFaces Attributes (CelebA) and WIDER face datasets and testing on Face Detection Data Set and Benchmark Home (FDDB). The experiment's accuracy was 93.9%..

Zereen and other in [16] Because of the COVID-19 pandemic, many organizations around the world are imposing face mask rules for personal protection. proposed a solution for automatic monitoring of face mask rule infractions for businesses. this solution is a two-stage facial mask detection technique that works well.The first stage involves extracting and clustering face landmarks, while the second stage examines clustered nose region. The all accuracy of the two stage model is an 97.13%, exceeding simpler single stage models, according to a rigorous accuracy evaluation on (5) types of example face photos (single-color mask, beard and mustache, skin-color mask, multi-color mask, and nomask).

Hung and other in [17] Face detection and identification are the two steps of this research. HOG features + SVM classifier are used in the face detection approach. The suggested face recognition model is based on a convolutional neural network (CNN). On the FEI, LFW, and UOF datasets, the model's efficiency is tested, and the results reveal that the suggested model achieves good accuracy.

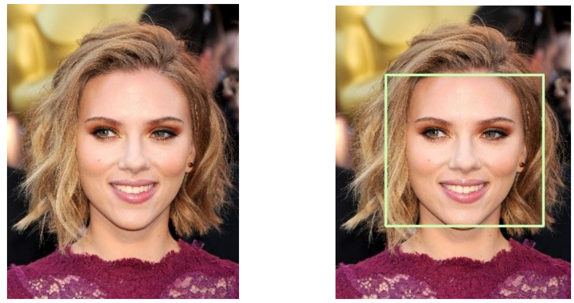
3. Face Detection System

A face detection system is a technology or system capable of detecting individuals from a photo or video frame. Face recognition systems normally work by comparing the facial attributes extracted from a given image with the faces previously stored in a dataset. Various strategies for facial detection and recognition have been proposed, however, no methodology compares to the human ability to recognize faces. It remains difficult for real-world implementations, as faces are recognized and remembered.[18,19] In this paper will explore how to face detection work using technique Dlib HOG based. The face detection system that presented consists of four steps include:

- Facial detection.
- Landmark localization.
- Facial Region Extraction.
- Facial Alignment.

3.1. Facial detection

In the face verification procedure, face detection is a crucial stage. There is a lot of methods applying in many types of research. [20] Using the HOG + Linear SVM detector, determine the location and size of the face in the image for each sample. (Figure 1) illustrates the original image as well as the image's detected face. (HOG) Histograms of Oriented Gradient descriptors that provide excellent performance comparing to another obtainable feature sets, and (SVM) Support Vector Machine based face detection that developed of the (SVM) based individual detection offered by (Dalal and Triggs). [21].



(a) (b)

Fig 1: (a)Original image, (b) Detected face.

HOG is a straightforward and effective feature description. This model is based on five filters (i.e 1- left looking, 2- back looking, 3-right looking, 4-front looking rotated-left, 5- front looking but rotated-right). The distribution (histograms) of the image's gradient directions are the features extracted. Gradients are large round edges and the corners that help us notice those areas, In general, the four basic steps to achieving HOG features, as follows: [22]

a) Apply the oriented edge filter [-1, 0, 1] on the horizontal and vertical input RGB color space images to compute the gradient images. The orientated edge filter is shown in Figure 2:

$$D_x = \begin{bmatrix} -1 & 0 & 1 \end{bmatrix}$$

$$D_y = \begin{bmatrix} -1 \\ 0 \\ 1 \end{bmatrix}$$

Fig 2: The edge filters - horizontally and vertically [21]

(Dx= the horizontal kernel, and Dy = the vertical kernel).

When the oriented edge filters are applied to the image, its result is as seen in Figure 3.

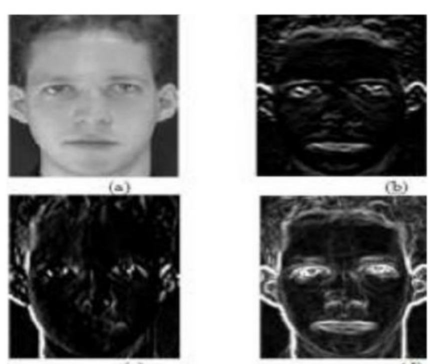


Fig 3: The oriented edge filter is applied to the facial image.

(a) The Original image, (b) image with horizontal-kernel applied, (c) image with vertical-kernel applied, (d) image with both horizontal and vertical-kernels applied.[22]

b) The orientation binding is the second phase in extracting HOG features, and it is based on a number of gradient-computation values got. Where the facial image is broken in cells of pixels, each pixel cell casts an orientation-based histogram channel weighted vote. The linear gradient vote consists of nine orientation bins ranging from 0o to 180o. The notion of orientation binning is depicted in Figure 4.

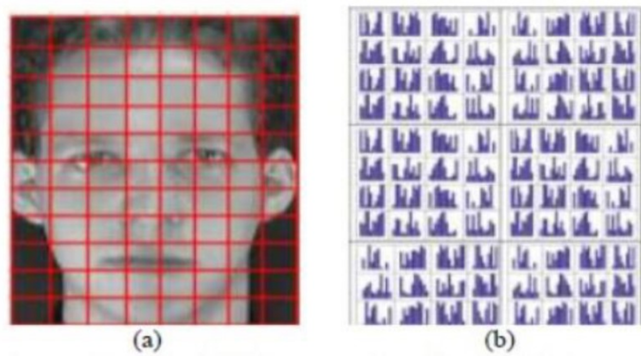


Fig 4: (a) split face image into cells, (b) compute cell histograms [22]

c) The third phase is "Descriptor blocks," which involves grouping nearby cells into a larger spatial region known as a block. To lessen the influence of varied contrast and illumination, normalization was applied to all the cells within block. It's vital to note the different types of blocks available; there are two types: rectangular R-HOG blocks and circular C-HOG blocks. R-HOG blocks are made up of square or rectangular cell grids. The number of pixels that make up each cell, as well as all the histogram bins or channels defines each rectangular block. Dalal et al. in [21] discovered that the most suited parameters for the human face are 16x16 block pixels divided into four 8x8 cells of pixels and nine histogram bins.

d) Parameters normalization, also known as block normalization, is the fourth phase. the (L1-norm, L1-sqrtv, L2-norm, as well as L2-hys) are 4 different ways to normalize parameters suggested by Dalal.et.at in[22].

Finally, after completing all the above HOG steps, the HOG features vectors are then fed into an SVM classifier to determine the facial area [21][22].

3.2. Landmark localization

Following detecting the face, operate to extracting the face area, for that, use one of the significant face landmarks detection algorithms is the cascade-regression detector to first define face landmarks. Is that it is built on a regression cascade that starts with the initial positions of the default mask of face landmarks and gradually changes them according to regression functions that differ with iteration.[23]

This detector generates a map of the facial structures by predicting 68 key-point coordinates given by (x, y) pairs. The predictor of (68 facial-landmark points) shown in Figure 5.

Fig 5: The (68 facial-landmarks) that determine the face structures.[23]

3.3. Facial Region Extraction

After defining the facial-landmark points, work to extracting the facial area without any portion of the background. Create a zero-value mask the same size as the original image, and then replace all the pixels that fall within the borders of those landmark points with the mask's corresponding pixels. The steps of the facial area extraction process are depicted in Figure 6.

(a) (b) (c)

Fig 6: face area extraction process.

(a)landmark localization in the image, (b) mask image,

(c) Replace the pixels within the boundaries of the face Landmarks with the mask image.

3.4. Facial Alignment

Face alignment is the next step in the face detection system. There are various methods for aligning the face, but, this paper employs a simple method based on facial landmarks (in particular the location of the eyes) and geometrical transformations. This method makes a normalized-rotation, translation, and scale-representation of the face based on the position of the eye area. [24] To align a face using facial landmarks and affine transformations, for example, we must do the following steps:[25]

a) The first stage is to detect the face region, and then use the facial landmark detection method to locate the eyes in the image. As illustrated in Figure 7:

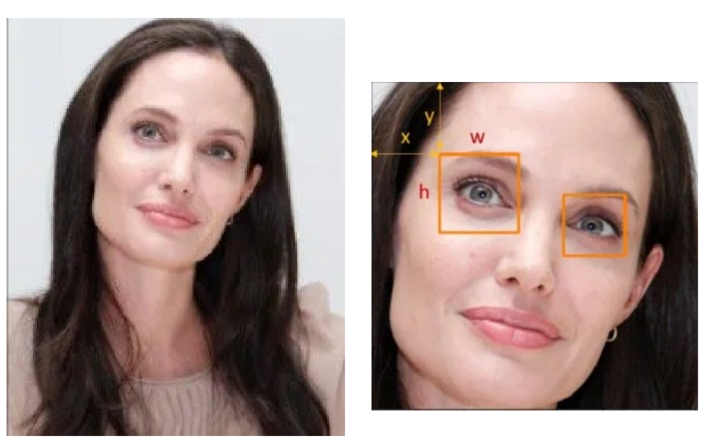


Fig 7: Detection face area and locate the eyes position [25].

b) The next step is to determine the center of the eyes and draw a line between center of them, followed by a horizontal line drawn from the first eye center, forming a right-angled triangle with the first line and the second eye center. The second phase is depicted in detail in Figure 8.

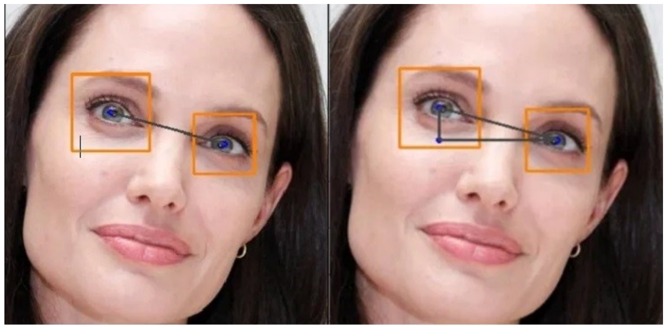
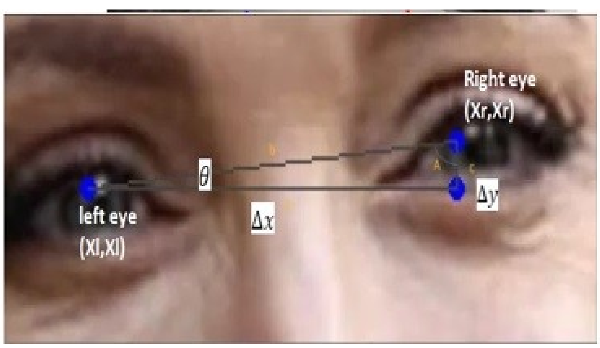


Fig 8: draw a right-angled triangle with the line that connects the eyes' centers and the straight line that runs through one eye's center.[25]

c) The third step is to calculate the rotation angle, which involves computing the angle formed by the horizontal line and the line connecting the two center eyes. To calculate this angle, first determine the length of two right triangle legs, then use the formula in (Figure 9) to get the required angle.



$$\Delta x = x_r - x_l$$

$$\Delta y = y_r - y_l$$

$$\theta = \arctan\frac{\Delta y}{\Delta x}$$

Fig 9: Computation of the rotation angle (θ),

Were ((xr,yr)= right eye coordinate , (xl,yl)= left eye coordinate, And (arctan) = the function returns angle in the unit) [25].

d) The final step rotates the image by an angle θ using an affine transformation. After conducting the rotation process, the rotation matrix and image are shown in Figure 10.

$$\begin{bmatrix} \cos(\theta) & -\sin(\theta) & 0 \\ \sin(\theta) & \cos(\theta) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

(a)

(b)

Fig 10: the Rotation process.

(a)- matrix rotation, (b) - image after rotation [25].

Finally, reduce the image size to 200×200 pixels. The implementation of the alignment method on the face image is shown in Figure 11.

(a) (b)

Fig 11: face alignment process .

(a) - image before alignment (b) - image after alignment.

4. Results and Discussion

The experiments result on evaluating the face detection in this paper ability suggest superiority in facial detection performance for detecting a variety of facials with accessories and makeup facials in the (DMFD) database. The Disguise and Makeup Database (DMFD) that presented in 2016 from The Hong-Kong Polytechnic University by (Wang, Tsung, and Ajay Kumar), that showed the detection failure because some images quality is not suitable to be detected by these face detector. It's evaluated by the Viola-Jones face detection (in the OpenCV)and the face parts extractor given by (VeriLook and Face++) to the automatically segment the facial region as well as face detection rate was a 77.4 % (559 out-of 2460 images failed to the face detection both by working on VeriLook or Face++ matcher). [26] in this paper, in the face detection system is we used using the Histogram of Oriented Gradients (HOG) and Linear (SVM) Machine Learning detector approach that is effective and can detect any disguise and makeup faces in the complex background and illumination variation in 99% (only 15 images out of 2460 images failed for the face detection system). The figure 12 shows some examples of images from Disguise and makeup face database (DMFD) dataset and the results of implementing the face detection system on it:

Fig 12: Example of some image pair before/after applying face detection system

Performance Evaluation of the top results on the (DMFD) dataset face detection system is shown in table 1.

Table 1 - Top results on the (DMFD) dataset.

Algorithms	Accuracy %
Viola-Jones [26]	77.4 %
This paper	99.3%

5. Conclusion

Disguised face detection and identification is an interesting and very challenging task. Not enough work has been prepared in detecting humans that hide their identity via covering their face with a variety of disguise accessories and facial makeup. This paper was presented to detect faces under different disguises and makeup. The face detection performed using Histogram of Oriented Gradients (HOG) + Linear SVM Machine Learning detector. The detection system tested on the Disguise and makeup face database (DMFD) dataset. The results shows successfully to detect faces in this dataset with high accuracy (99.3%) in different conditions such as the complex background and illumination variation. The detection system that used can be future applied and improved by increasing the number of images or by using the other dataset that contains faces more hard of (disguise and makeup facial) or designing a deep learning model to detect all face images in (DMFD). This might be extremely valuable for the law enforcement and another organization in identifying criminals and those anyone who covers/hides their identities.

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