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Facial image detection based on the Viola-Jones algorithm for gender recognition

Buraq AbedRuda Hassan*, Faten Abed Ali Dawood

Department of Computer Science, College of Science, University of Baghdad, Baghdad, Iraq

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Abstract

Facial gender recognition is an important and attractive research topic due to its extensive use cases, including gender demographic scanning, targeted advertising, access control, and visitor profile identification. The framework of the proposed method for face detection face consists of Adaboost, Integral Image, Haar- features, and Cascade Classifier. The LFW dataset containing 13,233 facial images was used.

Keywords: Face detection, Haar-Like Feature, Viola-Jones method
2020 MSC: 65D18

1 Introduction

The facial image is considered to be a reliable indicator for gender detection. Every human has a distinctive face that may be used to identify them from other people. In computer vision, gender may be inferred from face [17, 10]. It is frequently utilized in systems such as identity verification via face scanning apps, authentication, clinical systems, and in the medical industry for visual surveillance, mobile phone face unlocking, Alipay's new face-brushing technology, security systems, etc. [11, 18]. Face detection and recognition technology add a fun technological component addition to making life simpler and faster.

It is an important part of our lives since it appears in many acts like paying for the face, unlocking a phone, and intelligently recognizing with the aid of cutting-edge technologies to guarantee the safety of our possessions and identities and to achieve the integration of life and technology [11]. The initial stage in the detection and recognition of the face when employing Viola-Jones is the capacity to tell apart faces from non-faces in images. Viola-Jones This method, which was first suggested by Paul Viola and Michael Jones in 2001, uses feature selection to find face patterns in images with a high detection rate and a low mistake rate. A new image represented by an integral image is created from the input image as part of a procedure in this approach for detecting facial patterns. There are several features in the integral image. To identify images, AdaBoost will choose one of these features to be utilized as a classifier component. With the Viola-Jones method, the optimum result is achieved by identifying if certain haar features are present or absent in an image and choosing particular haar features that will be utilized to modify the threshold. Cascade Classifier then determines a face area in an image as the final classification [6].

*Corresponding author
Email addresses: asds.yy899@gmail.com (Buraq AbedRuda Hassan), faten.dawood@sc.uobaghdad.edu.iq (Faten Abed Ali Dawood)

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2 Related Work

In the literature investigated, several approaches have been proposed for facial image detection, given many published studies about the objectives of this work. Edy Winarno et al [20] propose a multi-view object identification system, to determine how many faces are there in an image. For the Viola-Jones technique of face identification, this system constructs cascades of face classifiers using the AdaBoost algorithm. The Viola-Jones approach, which involves numerous processing steps, can lower face detection errors. It can identify and count the faces in an image. The test results have shown a level face detected accuracy of 93.24%. Laxmi Narayan Soni [15] proposes using the Viola-Jones method of huge and high-resolution images where the detection rate is 97.41%. Al-Mukhtar [1] proposes how to detect, track and blur a single face in a video frame by using the Viola-Jones algorithm for detecting the face and kanade–lucas–tomasi (KlT) feature tracker "algorithm to track a set of feature points across the video frames. The findings can be used to obscure faces when depicting painful view that includes deformed faces in war reports or crimes, for example. [8] proposed a method for improving dark images that take into account local pixel modification. The results of the studies demonstrated that their approach significantly increased image quality. However, the Images contained artifacts.

Liang et al [9] propose employing a face templates approach for locating a face edge with accuracy, bypassing face detection, that can only determine a binding when there is no backdrop, passing both eyes, and a face with a specific aspect ratio. Face detection in this instance uses the case's face template, and ultimately, an experiment's success rate of above 90% for face detection. bringing about a practical method for identifying the face in a favorable situation. Vikram [19] proposed implementing the Viola-Jones technique and tested it on several facial image databases from various image collections. An accuracy of 92% is provided by a database that contains images taken under various lighting conditions.

3 Methodology

In general, face detection is a necessity for gender recognition. In the proposed model, to detect the facial image we use the database of LFW. Figure 1 depicts the overall framework of the suggested model for detecting face image.

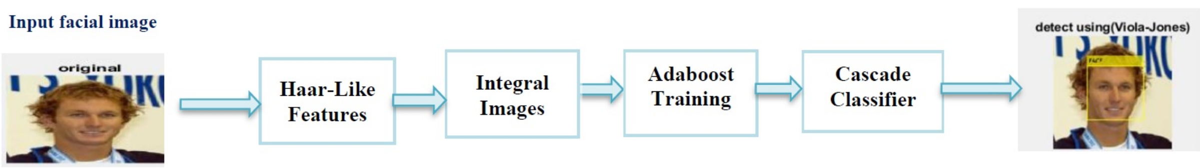


Figure 1: Face detection using (Viola Jones algorithm)

3.1 Facial Images Database

LFW database is the most often used benchmark for gender identification, Even though was initially developed for unrestricted face recognition such as facial expression, lighting, background, gender, age, color, camera quality, clothing, hairstyles, and other parameters. freely accessible for scientific purposes. It contains 13,233 images of 5749 person (10,256 males and 2977 females) [3]. As show in Figure 2.This database was created and maintained by researchers at the University of Massachusetts. Face parts in the images were detected through the Viola-Jones face detector.

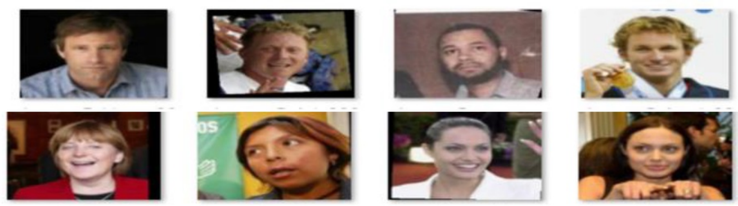


Figure 2: Samples of the facial images from the LFW database.

3.2 Face Detection using Viola-Jones Algorithm

A face detection technique that produces speedy, accurate, and effective results is Viola-Jones [7]. The algorithm has been implemented in the software 'Matlab' using the method Vision.CascadeObjectDetector [6]. The main objective of face detection is to identify and locate faces in images. If there are faces present, this process also aims to find them. Working with a variety of face changes, such as orientation, expression, and skin tone, is said to be one of the fundamental problems in facial detection. Furthermore, extrinsic factors including complex backdrops, inconsistent lighting, and the image's quality may play a substantial role in the detection process [22]. Full view frontal upright faces are necessary for Viola-Jones [21]. A window used in the procedure read an input image while searching for traits of a human face. When sufficient features are detected, it is stated that this window type of the image is a face [22]. It is necessary to scale the window and repeat the procedure to bring faces of various sizes. The approach is applied to each window scale separately from the others. Due to the calculating of the various image sizes, this approach is fairly time-consuming. To reduce the number of features every window must be checked, and each window is moved through stages, in order. Early levels have fewer features to check and are thus much simpler to complete than later levels, which end up having more elements and are therefore more difficult. Each level's evaluation of the features is gathered, and if the value obtained falls short of the required amount, the level is failed and this window will not be recognized as a face [9]. The algorithm has very low rates of false positives and very high rates of detection [16]. There are four main phases to the Viola-Jones face detection method, including (Haar-Like Features, Integral Images, Adaboost, and Cascade Classifier) such as presented in Algorithm 1, and will be illustrated in detail as follows.

Algorithm 1 Face Detection using Viola-Jones [4]

```
Input: original test image
output: image with face indicators as rectangles
for i ⟵ 1 num of scales in pyramid of images do
 Downsample image to create image_i
  Compute integral image, image_ii
  for j ⟵ 1 to num of shift steps of sub-window do
    for k ⟵ 1 to num of stages in cascade classifier do
     for l ⟵ 1 to num of filters of stage k do
       Filter detection sub-window
       Accumulate filter outputs
   end for
   if accumulation fails per-stage threshold then
       Reject sub-window as face
       Break this k for loop
    end if
   end for
   if sub-window passed all per-stage checks then
       Accept this sub-window as a face
    end if
 end if
end if
```

3.2.1 Haar-Like Feature

The majority of the properties of human faces are identical. We can match their attributes by using the Haar feature. Instead of taking the input image's intensity into account, features are extracted in computer vision. There are white and black patches on this Haar-like feature. The intensities of the white zone are added together to create one value, while the intensities of the black region are added together to deduct that value [16].

$$IImg = \sum_{1\leq x\leq K}\sum_{1\leq y\leq K} Img(x,y)1Pn(x,y)\text{is white} - \sum_{1\leq x\leq K}\sum_{1\leq y\leq K} Img(x,y)1Pn(x,y)\text{is black} \tag{3.1}$$

The attribute associated with the pattern Pn of the image Img is Determined via an equation [22] assuming which Img and Pn appear as an image and pattern, respectively, each equal in size $K \times K$ [because the value K=24]. Features edge, features for line diagonal, and features for line-straight are three different forms of Haar-Like Features that aid in information extraction from the input digital image. This makes it easier to recognize a person's face [16].

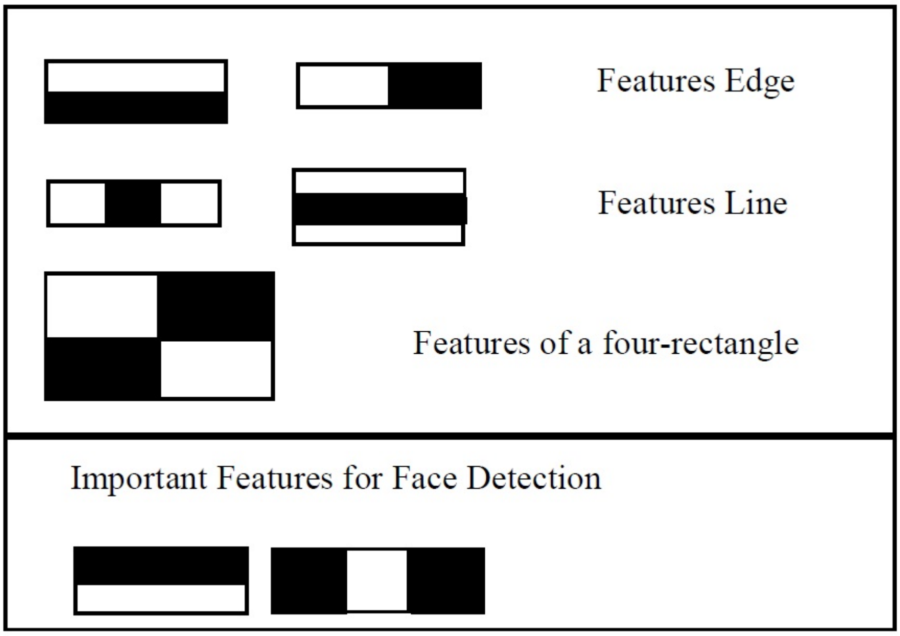


Figure 3: Haar–Like Feature [16].

3.2.2 Integral Images

Using an intermediate representation for the picture called an integral image, Haar-like features are calculated relatively quickly. Equation displays the integral image calculating formula (3.1). The integral image at location x, y contains the sum of the pixels above and to the left of (x, y) [5].

$$p(x, y) = \sum \sum I(s, t); \ 1 \leq x \leq M, \ 1 \leq y \leq M$$

Here P is the integral image as shown in Figure 4. The original image is I. M is the dimension of the rectangle. The integral image at location 1 in Figure 4 is the sum of pixels in region A, at location 2 it is the sum of pixels in region A+B, at location 3, it is the sum of the pixels in region C+A, and at location 4, it is the sum of the pixels in the region A+B+C+D [5].

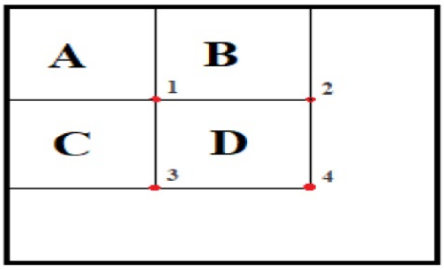


Figure 4: Integral Image [5]

3.2.3 Adaboost

The AdaBoost (Ada: Adaptive, Boost: Boosting) method may simultaneously perform feature selection and classifier training. The algorithm is iterative. The fundamental principle behind it is to train many classifiers (weak classifiers) on the same training set, then combine these weak classifiers to get a stronger final classification (strong classifier). Modifying the data distribution allows the method to be implemented. The accuracy of the most recent global classification and the accuracy of each sample's classification in each training set is used to calculate the weight of each sample. To train the lower classifier, fresh data sets with changed weights are provided. The final decision classifier is created by combining the classifiers from each training. AdaBoost classifier may be used to remove certain extraneous training data characteristics and concentrate them on the important training data.The face is assessed when the input image's eigenvalue exceeds the threshold value, therefore finding the best threshold value is essentially the first step in training the best weak classifier. In ordinary images, areas with human faces only take up a small portion of the overall image. Therefore, the procedure is quite demanding and time-consuming if all local areas must go over all the characteristics. More possible samples should be evaluated to reduce computing time [10, 19].

3.2.4 Cascade Classifier

After choosing the greatest qualities in each window, now must choose which of these windows contains faces [14]. The first discovered faces must proceed through many cascaded phases before finding the positive windows. Every level lowers the percentage of false positives, or areas that are mistakenly identified as faces. A classifier is created for each stage utilizing a few features. Every level after that adds more and more features, increasing the complexity of the classifier. Figure 5 illustrates this. Every sub-image will be categorized at the first level of classification using a single feature. If the images match specific Haar features, the classification result is T (True), otherwise, it is F (False). The classification will leave around 50% of the sub-images to be categorized in the following stage. The second classification result produces the signs T and F depending on whether the image fills the integral image process or not. More precise requirements are required as the level of categorization rises for the feature to provide a large amount of data. There will be a 2% reduction in the overall number of sub-images on the categorization. The final classification result produces a sign T for full Adaboost and a sign F for empty Adaboost [19]. Therefore, only the area that completes all steps is categorized as a face. The accuracy of detection increases with the number of steps in the cascade classifier. But doing so requires more time for calculation. The classifier's calculation time increases with the number of steps. There is a trade-off between precision and speed as a result [2, 12].

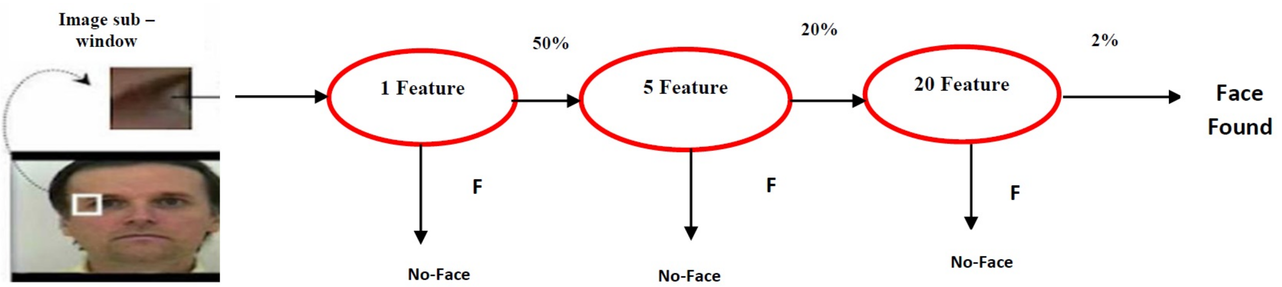


Figure 5: Cascade classifier. The first weak classier obtain a rate of detection 100% and a rate of false positives around 50%. A second weak classifier manages a 100% rate of detection and a 40% rate of false positives. The third feature classification achieves a rate of detection of 100% and a 10% rate of false positives (2% total of all three) [13].

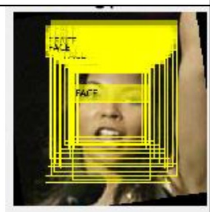
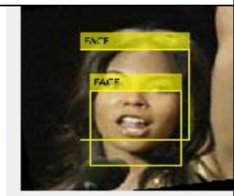
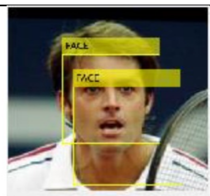
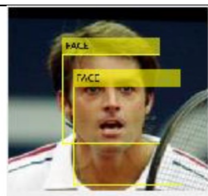
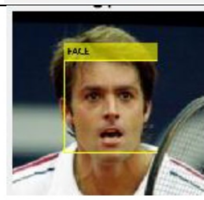
4 Experimental Results

This work was performed using Windows 10 with 8.00 GB of physical memory with an Intel Core i7 processor. MATLAB R2020a has been used with the LFW dataset. 13,233 facial images (10,256 males and 2977 females) at 250×250 pixels RGB size were used. The face was detected by Viola-Jones. in a face detection process. Threshold values were effect significantly on the detection results. A larger detection mistake will occur if the threshold is set incorrectly. the best-automated choice must be determined. Even though the number threshold value is adamant about specifying the necessary parameters as a parameter of the Mergethreshold value on Matlab in the selection, the region of the face is examined. depending on the cut-off value of the detection result set one checkbox is provided around the target. Can help increase the threshold value and Reduce fake detection around the object [15]. The ideal threshold value was discovered following the testing of the threshold parameter values between 0 and 10. Table 1 displays several instances of various threshold values.

5 Conclusion

In this paper, Viola-Jones technique is used to detect faces in each dataset. High detection rates are using the Viola-Jones technique. for the experiment, the LFW dataset is used, this technique was implemented using MATLAB (2020a).

Table 1: Illustrations of detection outcomes based on various the threshold values.

Samples of LFW Dataset	threshold value			
	0	1	2	3
female				
male				

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