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Forensic Analysis of Faces on Low-Quality Images using Detection and Recognition Methods

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Abstract

Facial recognition is an essential aspect of conducting criminal action investigations. Captured images from the camera or the recording video can reveal the perpetrator's identity if their faces are deliberately or accidentally captured. However, many of these digital imagery results display the results of image quality that is not good when seen by the human eye. Hence, the facial recognition process becomes more complex and takes longer. This research aims to analyze face recognition on a low-quality image with noise, blur and brightness problem to help digital forensic investigator do an investigation in recognizing faces that the human eye can't do. The Viola-Jones algorithm method has several processes such as the Haar feature, integral image, adaboost, and cascade classifier for detecting a face in an image. Detected face will be passed to the next process for recognition call Fisher's Linear Discriminant (FLD), Local Binary Pattern's (LBP) and Principal Component analysis (PCA). The software's facial recognition feature shows one of the images in the database that the program suspects has the same face as the analyzed face image. In conclusion, from the analysis we determined that LBP approach is the best among the other recognition methods for blur and brightness problem, bet found PCA method is the best for recognize face in noise problem. The software's facial recognition feature shows one of the images in the database that the program suspects has the same face as the analyzed face image. The position of the face object in the image, whether or not there is an additional object that was not previously included in the image in the dataset, as well as the brightness level of an image and the color of the face's skin, all affect the accuracy rates.

Keywords: *face forensic; low-quality image; face detection; face recognition*

1. Introduction

Facial recognition is widely used for all form of security. including unlocking devices, validating personal information in public areas, following someone for investigations, locating the missing person, and even in other fields [1]. Capturing facial images can be done through CCTV cameras, smartphones, and other equipment to capture an object into a digital signal. However, there are certain issues with the quality of digital images, such as pixel quality from the camera [2], image blur [3], light intensity that is too little or too much [4],[5], and noise [6]. Poor image quality can result from a number of factors, including the camera's capacity to catch light, its undesirable location, and the amount of or absence of light that illuminates the subject.

Numerous studies have demonstrated that due to picture quality issues, images derived from screenshots or direct recordings can convey partial information [7 – 9]. The following issues can reduce the amount of information in the image: (1) Numerous factors, including inadequate lighting for taking pictures, the camera's lens's low pixel resolution, the camera's inability to capture moving images, electromagnetic wave inference, and others, contribute to noise. As described by [10], According standards, sensitivity is the ISO film speed equivalent. "Excellent" image quality is defined as having an SNR requirement of 40:1, "good," or less than 5:1 at average brightness. Other noise type included gaussian, poisson, speckle, localvar and then salt-and-pepper noise. However, we only concentrate on Gaussian noise when it comes to the noise problem. (2) Object movement while the camera lens is taking the picture, using an unfocused optical device, using a wide-angle lens on the camera, atmospheric interference, and short exposure levels that lower the number of photons the camera lens is able to capture are just a few of the factors that can lead to blurry images. The sharpness of the device quality image or system's Modulation Transfer Function is determined by the contrast at a certain spatial frequency

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(quantified in cycles or line pairs per distance) in comparison to low frequencies (MTF). Compared to the outdated vanishing resolution test, the 50% MTF frequency corresponds with subjective sharpness quite well. (3). A crucial element in photography is light. Sometimes a lens flare occurs after a photo is taken, creating light flares and affecting the brightness all around it. As a result, the ISO 18844:2017 standard is used to enable assessments of the performance of digital cameras utilizing the picture data they produce. Brightness may be altered by varying the number of constants at each pixel in the image.

One method for improving the comprehension of visual image information is to use picture preprocessing, as done by [11],[12]. Image preprocessing is the process of enhancing an image for object extraction by lowering noise, adjusting brightness, and enhancing data quality. Image preprocessing techniques like noise filtering, deblurring, and brightness adjustment were applied in this study. [13].

The first step in face recognition is face detection, which is accomplished by extracting facial objects. [14],[15], one of the face detection methods is the viola-jones algorithm introduced by [16] and confirmed by [17] it combines several steps which are well-liked and frequently used in research to identify a person's face in an image. As a result, it has excellent accuracy.

Following face detection, we decide three different techniques FLD, PCA and LBP will be used to facial recognition. It is possible to recreate the face in image. We using Labeled Face in the Wild (LFW) and the face94 datasets to compare the accuracy of finding matches in each dataset and the recognition methods. There has been a lot of research done before on the subject of facial recognition in digital image. However, none of these studies have ever been done on images with low-quality, particularly in terms of blur, noise, and brightness. Investigations must conduct a more thorough analysis of face recognition in poor-quality images in cases where there may be evidence of a person's face captured on camera with poor image results.

2. Research Methods

Face recognition is the process of searching identical data which actions to take in order to attain a particular aim or target. A methodical technique was used to gather data, turn it into information, and add it to factors that must be taken into account when recognizing face. Figure 1 illustrates the process for facial recognition, which includes preprocessing, detecting facial objects in the image after extraction, and facial recognition as the final step.

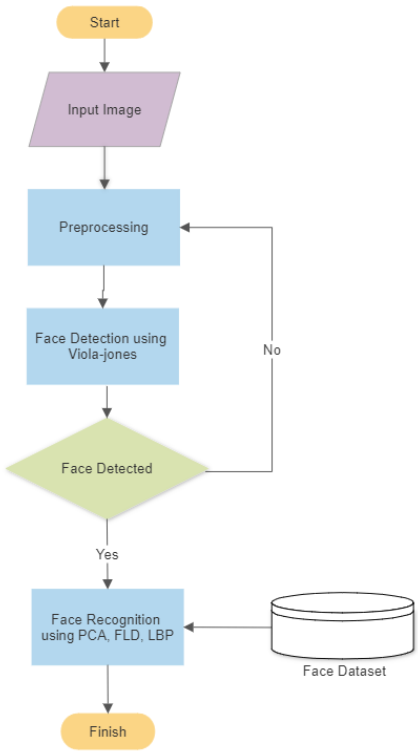

Figure 1. Architecture of Proposed System

2.1 Dataset

We employ datasets that have previously passed several tests in order to gauge facial recognition capacity. With more than 13,000 facial images gathered from the internet, Labeled Face in the Wild is a facial photo database created to study facial recognition problems unrestrictedly. The LFW dataset has been extensively used in facial recognition research from a variety of angles. [18–20]. Second dataset is face94 with more than 3000 facial images that has been used in research [21–23]. Sample images from both datasets are displayed in Figure 2.

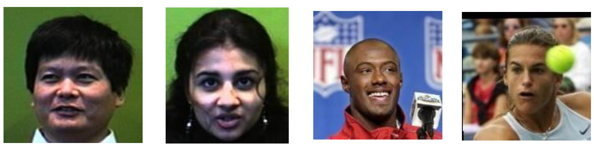

Figure 2. Face94 Dataset and LFW Dataset

Every dataset needs to be filtered first, and then modified to be consistent with the training data, as we use a variety of recognition techniques, each of which has specific dataset requirements. Table 1 shows dataset image that we use for analyzing.

Table 1. Test and Training Image in Datasets

Method	Training Image		Test Image
	LFW	Face94	
PCA	3845	3000	30
FLD	3034	3000	30
LBP	3577	2886	30

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2.2 Preprocessing

Handling data to extract relevant information or transform it into useful information is what signal processing entails [24], [25]. Digital image processing is divided into several image processing processes, including: (1). Enhancement is the process of image manipulation so that the image results are clear. (2). Restoration is a process to eliminate and minimize defects in an image. (3). Reconstruction is an operation to reshape objects from several parts of an image. (4). Segmentation is the breaking of an image into several parts with certain criteria. (5). Extraction is the process carried out after segmenting the image. (6). Image pattern classification is the process of marking an object if the object has a match with other objects outside the image.

2.3. Face Detection

In 2001, [16] designed a fast and accurate method to detect faces and other objects in digital images. The Viola-Jones method has four phases in the process. (1). An integral image is used to speed up calculations on very large Haar features by dividing the image into several groups of image cells. (2). Adaboost has a role in ensuring the speed level of face detection in a necessary process. (3). Cascade classification is carried out in stages where each level gives a sub-image that is believed to be not a face.

2.4 Face Recognition

Although there are other techniques for recognizing faces, in this study we examine three of them: (1) Principal Component Analysis, (2) Fisher's Linear Discriminant, and (3) Local Binary Patterns. While the recognition model is the same across all of these techniques, the training data requirements and matrix calculation requirements vary.

2.5 Confussion Matrix Validation

Two cells in the Confusion Matrix's table contain predicted values, while the other two cells contain actual values [26]. Four cells in the confusion matrix show the results of the categorization process, such as: (1). True Negative (TN) predicts a negative outcome and is correct. As a result, the system predicts that the faces will not be the same, and this is accurate. (2). A true positive (TP) forecasts a successful outcome. Since the faces are similar, as predicted by the method, they truly are. (3). False Positive (FP) refers to a prediction of a positive that is untrue because the system assumed that the faces were identical when they were not. (4). False Negative (FN) makes an inaccurate negative prediction. The face is exactly the same despite the system's prediction that it is not.

The accuracy, precision, and recall calculations show how well the system can identify facial objects using these four classifications. How accurately the model can classify actual data is determined by accuracy. Precision is the degree to which the predicted outputs of the model match the provided data exactly. How successfully the model recovers identical information is described by these words, recall or sensitivity.

3. Results and Discussions

Our goal is to analyze a low-quality image, particularly its blur, noise, and brightness, which must first initiate preprocessing in order for us to detect or recognize the face.

3.1 Deblurring

Blur issues need to be described in broad terms with specifics that are written in a methodical manner. Each issue should be described using the pertinent value. Every citation in the body of the text must be listed in the bibliography or references section.

The blind deconvolution technique works well when there is no knowledge of the distortion (blur and noise) as shown in Figure 3.

Figure 3. Image with blur

When deblurring a small sized PSF, a small-sized array called UNDERPSF is used as an initial estimate of the PSF. It is a 4-pixel array that is smaller than the actual PSF in each dimension as shown in Figure 4.

Figure 4. Deblurring using Underpsf

Using an array bigger than UNDERPSF and an OVERPSF for initial PSFs that are 4 pixels longer in each dimension than the actual PSF, one can deblur large PSFs as shown in Figure 5.

Figure 5. Deblurring using Overpsf

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By reducing the effects of ringing by determining the weighting function INITPSF stands for the initial PSF, which is identical to the actual PSF in size, INITPSF is able to recover images with less blurring along the sharp intensity contrast area and the image borders as shown in Figure 6.

Figure 6. Deblurring using Initpsf

Deconvblind with a weight array and an increase in the number of iterations by 30 as shown in Figure 7.

Figure 7. Deconvblind

Decondvblind with additional restrictions on PSF. The FUN function returns a modified PSF array that deconvblind uses as shown in Figure 8.

Figure 8. Deconvblind reduce psf size

Less deblurring errors are revealed by using the blind deconvolution approach to the blur ratio, which improves information visibility and leads to a lower squared error. These findings support hypothesis from [27].

3.2 Denoising

Denoising the image using an adaptive median filter algorithm (a type of linear filter). The median filter algorithm does some smoothing with small variants, but more smoothing with large variants, as in figure 9 for test image noise and Figure 10 for denoising result.

Figure 9. Image with noise

Figure 10. Denoise image

From the experiment, the filter is efficient at removing noise and displaying more information on image because it only deals with the problematic pixels while keeping the image shape. The same result is also in [28].

3.3 Brightness Adjustment

Imadjust, Histeq, and Adapthisteq are three functions that can adjust brightness. Figure 11 shows sample of low brightness image, the adjustment result by comparing the effectiveness of the three processes while using the default settings.

Figure 11. Low brightness image

By reducing the input intensity image values to 1%, IMADJUST enhances image brightness as shown in Figure 12.

Figure 12. Adjustment image using imadjust

HISTEQ performs histogram equalization by boosting the image's contrast and altering the intensity image's values as shown in Figure 13, so that the output image's histogram roughly resembles the specific histogram.

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Figure 13. Adjustment image using histeq

Similar to Histeq, ADAPTHISTEQ also performs histogram equalization, but it only works on the pixel-level of the image as shown in Figure 14.

Figure 14. Adjusting image using adapthisteq

The outcomes are shown by enhancing the image quality to make the information in the digital image more visible, achieving the same result as [29].

3.4 Face Detection using Viola-jones

By loading a box over the image, the Cascade Object Detector function finds faces in the image. then categorizes whether or not a face object is present; it has various scales but a constant ratio. Since there are no other objects to recognize after the face has been detected as in figure 15, the system will cut each square to increase the accuracy of recognition rates.

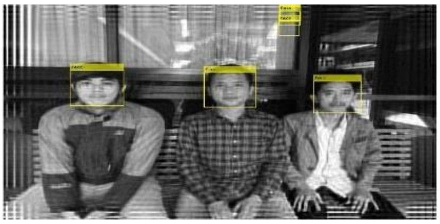


Figure 15. Viola-jones face detection

It detects faces very effectively, supporting the assertion that it performs well [29–32], However, there is a mistake where an object that is not a face, but it is not a problem.

3.5 Face Recognition

The process of creating an eigenface for each image in the dataset after the face has been found involves looping calculations on the dataset image to produce a data array containing the distance value or equivalent value shown in Figure 16, calculating to obtain the minimum value because it resembles or is the same as the object in the sample image, and then comparing the results to determine the face [33].

```
Columns 1 through 12

  1.8066    1.5079    2.3891    0.8396    1.4483

Columns 13 through 24

  1.3711    2.9219    3.8254    3.8081    0.7493

Columns 25 through 28

  4.2953    3.1649    1.4309    0.7419
```

Figure 16. Distance value from test image with every training image

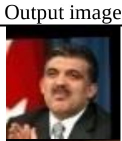
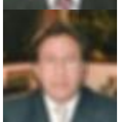
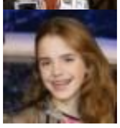
If a facial image is obtained that has the smallest value, indicating that the two face objects are identical. For example, in figure 17, the test image and recognized image both have the smallest values, indicating that the two face objects are identical.

Figure 17. Test image and recognized face

3.6 Recognition Analysis Rate

We test the system using a set of images, in table 2 and table 3 we show ten analyzing results for each dataset, honestly, we run 30 analize for each dataset for the confirmed result.

Table 2. Recognition Analysis with LFW Dataset

Sample	Detection	Output image	Accuracy	Precision	Recall	Recognized
			98%	2%	17%	True
			89%	1%	0%	False
			96%	2%,	60%	True

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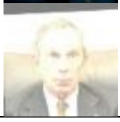
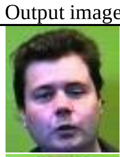
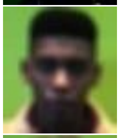
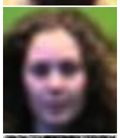
Sample	Detection	Output image	Accuracy	Precision	Recall	Recognized
			96%	1%,	20%	False
			99%	0%,	0%	False
			100%	0%,	0%	False

Table 3. Recognition Analysis with Face94 Dataset

Sample	Detection	Output image	Accuracy	Precision	Recall	Recognized
			99%	0%	0%	False
			97%	17%,	100%	True
			99%	33%,	100%	True
			100%	95%	100%	True
			99%	0%	0%	False
			100%	100%	95%	True

The validity calculation, which determines the values of accuracy, precision, and recall using the confusion matrix, explains how well all recognition algorithms do in recognizing face objects. When you can tell a face apart from another's face, you might say that your accuracy is high. When the recall value used to find the same face from a sample image is 0%, there are no faces that are the same as the sample image, while when the precision calculation value of the two analyzed datasets is mostly below 5%, the method has an error in predicting the same face. The results of the analysis show that each method's accuracy for facial recognition is determined using the detection rate. Each dataset contains 30 images that have been analyzed, 10 images for each image problem. Figure 18 and table 4 shows a graph and data for the LFW dataset's recognition rate.

Table 4. Recognition rate in LFW dataset

Method	Noise	Blur	Brightness
PCA	60%	80%	0%
FLD	0%	0%	20%
LBP	40%	80%	90%

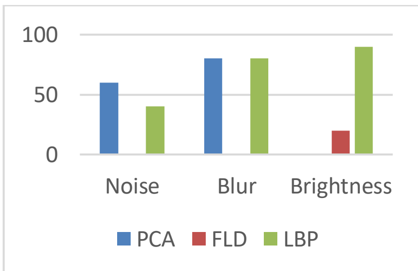


Figure 18. Recognition rate in LFW dataset

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The LBP method outperformed the other methods in the LFW Dataset, as demonstrated by the fact that faces were recognized in every image problem because there was no zero value between them. The only drawback of the PCA method is the brightness issue. Table 5 and Figure 19 shows a data and graph for the face94 dataset's recognition rate.

Table 5. Recognition rate in Face94 dataset

Method	Noise	Blur	Brightness
PCA	100%	80%	10%
FLD	0%	20%	0%
LBP	50%	100%	90%

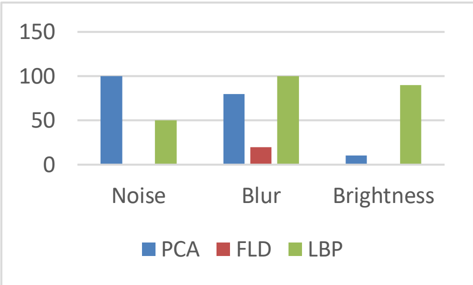

Figure 19. Recognition rate in Face94 dataset

With the exception of the noise issue, LBP method still produces better results than the other at and face94. The poor performance of the FLD method in both datasets suggests that FLD is incompatible with image analysis in large training datasets.

4. Conclusion

Viola-Jones can be used to detect faces in low-quality images by preprocessing them, according to research and discussion findings. The comparison of the three recognition methods then reveals that LBP is better than others recognition method, with the exception of the noise issue, where LBP lags PCA. But LBP can recognize faces in digital images more quickly and easily than the competition; it only needs four minutes to do so. As a result, it can be concluded that viola-jones method and LBP recognition method can be effectively combined to identify human facial recognition in problematic digital images.

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