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Rapid Black Face Recognition Accuracy in Controlled Environment Using LBPH

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ABSTRACT: In recent years, Computer vision algorithms have never been so good at distinguishing human faces. National Institute of standards and Technology (NIST) reiterated last recently that the best algorithms got 25 times better at finding a person in a large database between 2010 and 2018, by missing a true match by only 0.2 percent in the times. But NIST's tests and other studies repeatedly have found that the algorithms have a harder time recognizing people with darker skin.

The proposed LBPH facial image recognition algorithm is robust and adapts to dark-skinned facial recognition systems. The experimental results on a database show a significant precision of facial recognition by the proposed method.

KEYWORDS: *Computer vision – NIST – algorithms – face recognition – darker skin – LBPH (Local Binary Pattern Histograms)*

I. INTRODUCTION

Facial recognition is the process of identifying or verifying the identity of a person using their face. It captures, analyzes and compares patterns based on the person's facial details such as the relative position, size, and/or shape of the eyes, nose, cheeks, and jaws. These features are then trained to search for other images with matching features. Facial recognition is popular and largely uses the personal identification method. This method uses only one additional device that is a camera, so it can be applied to various systems. In addition, the facial recognition process can be performed without interaction of the device with the person(1).

Moreover, there are many factors that affect the accuracy of facial recognition. Environmental factors, algorithms, and the quality of the image database are the factors that have most often affected the accuracy of recognition(2). The other factors that impact on face recognition accuracy are face shape, face texture, glasses, hair, and also the factors that unstable such as lighting, etc. Thus, any controllable factors should be well controlled to have a minimal impact on the recognition system. As described in Jafri and Arabia's work(3).

The NIST test challenged algorithms to verify that two photos showed the same face, similar to how a border agent would check passports. At sensitivity settings where Idemia's algorithms falsely matched different white women's faces at a rate of one in 10,000, it falsely matched black women's faces about once in 1,000—10 times more frequently. A one in 10,000 false match rate is often used to evaluate facial recognition systems(4). Many intrapersonal factors of face that have to be concerned while using the face recognition system. These factors can cause missed face recognition in case of individuals who have a similar face appearance(5). However, the external factors are due to the surroundings of the facial recognition system. These types of factors can cause some changes in the appearance of the face in the process of image acquisition. There are several external factors which can be uncontrolled and varied while using the system. Numerous publications of facial recognition algorithms have shown each algorithm having characteristics and offering high accuracy in facial recognition from different aspects. For these reasons, facial recognition becomes a good alternative method.



Despite literature reveals that a lot of research work has been carried out on face recognition. From the prior work(6), the selection of the algorithm is a very difficult part of the implementation of a recognition system having a black-skinned person database, as it is a difficult system to control due to environmental factors that can be very unfavorable for a good quality of identification. These factors also strongly affect the accuracy of facial recognition.

This research studies the efficiency of the Local Binary Pattern Histograms (LBPH) in black facial recognition algorithm which has high precision and reliability.

Consequently, this experiment will be helpful to know if LBPH algorithm have better accuracy in black face recognition for the face recognition systems which have the similar conditions.

The state of the problem, facial recognition algorithms and the related theory of facial recognition are described. This work uses LBPH in the facial recognition process. This algorithm is available in the Computer Vision Library (OpenCV), which contains several computer vision and image processing functions. There is a lot of research and publication on this algorithm and has demonstrated acceptable high accuracy of facial recognition. Besides, OpenCV library is open source which is convenient to use without cost, easier and good for long term practical use.

The rest of the paper is organized as follows. Section 2 provides an overview of algorithm and the variation of factors. Section 3 gives an implementation and also its different conditions. In section 4, the results, evaluations, and discussion are described. Finally, the summary, conclusions and future work of this paper are presented in Section 5

II. OVERVIEW OF PROPOSED ALGORITHM

A. Local Binary Pattern Histogram

The local binary pattern histogram (LBPH) is one of the simplest facial recognition algorithms based on the representation of faces proposed by Ahonen et al(7). This method is based on local bit patterns (LBP), which is first proposed as a texture description method. In the texture classification approach, occurrences of LBP codes in an image are collected in a histogram. Classification is then performed by calculating similarities of simple histograms. However, considering a similar approach for the representation of facial images results in a loss of spatial information and, therefore, texture information should be codified while also retaining its locations. LBPH has the advantage of being invariant to light intensity, but it takes longer to process than the holistic approach(8).

A histogram of the labeled image $f_i(x, y)$ can be defined as :

$$H_i = \sum_{x,y} I\{f_i(x, y)\} \quad i = 0, \dots, n - 1 \quad (1)$$

In which n is the number of different labels produced by theLBP operator and

$$I(A) = \begin{cases} 1 & A \text{ is True} \\ 0 & A \text{ is false} \end{cases}$$

The histogram is obtained from the images containing information on local facial micro-patterns, including the edges of the face, the location of the eyes, and other flat areas for adequate facial representations.

B. Testing Factor

Many factors affect the accuracy of facial recognition and some factors have a chance to emerge when using the practical system according to previous studies.

The first is the quality of the database, there are many factors that need to be controlled in the image acquisition process, such as image quality, image size, noise levels, levels. of light, facial expressions, facial views, glasses, etc. Thus, the image database should be established avoiding as much as possible its factors affecting the images.

Second, the quality of the input image, this factor is completely unpredictable and difficult to control when deploying the facial recognition system. Although the image preprocessing phase may improve the quality of the input images, some surrounding factors may not be eliminated, such as facial expressions and the light levels of the surroundings.

Therefore, this research studies the disruptive factors: facial expression and light levels, which can occur when using the facial recognition system. In addition, this work performs a test on the accuracy of facial recognition algorithms in order to prove whether the algorithms are more suitable to apply in black skin facial recognition system.

























III. IMPLEMENTATION

This section presents the implementation steps including the face image database creation, the study of face recognition algorithms LBPH.

A. Images Database

In order to create the database, images of students and professors were collected from a camera. Thus, this process can obtain a set of still images per student and teacher. Additionally, the image was captured from different light controlled environments.

TABLE I: Example facial image from database

Luminosity Face position	0	1	2	3
Frontal				
				
				
				
				
				

Each student and professor had four images in a reference database, 150 images of manual capture. All images were collected in four environments with controlled lighting. Most of the images collected are similar to those in Table I. In the frontal position, a normal face. However, this method takes time to collect the images of each student and teacher, it is impractical for the students to come at a specific time to take the photos. Thus, this method is inappropriate for a very large collection

IV. RESULTS, EVALUATIONS AND DISCUSSIONS

A. Brightness Factor

As described, the light exposure factor was tested in the experiments. the factor was varied within the possible range which could give an image usable in practice. The results of variations in light exposure, including their challenges, will be described as follows. Exposure to light is a difficult factor to control in the automatic facial recognition system. The light can affect the details of the vectors that represent faces, and it can cause the facial recognition error.



B. Recognition accuracy

The results of facial recognition tests based on still images with the variation of the light factor will be described. The first experiment is facial recognition based on still images in each range (0, 1,2,3) of light as shown in TABLE I. This is the test with the image. This test was performed using a set of 1xn student identification tests that have four images in the database. The faces of the students and teachers in the entire test belong to the people who exist in the reference database. These images were tested by the LBPH algorithms. The result of this experiment is presented in Table II. The accuracy of the results is calculated from the ratio between the number of correct recognitions and the total number of faces.

TABLE II: Result accuracy without factor

LBPH algorithm	Total faces	correct	Accuracy(%)
	150	118	78,6

TABLE III : Result accuracy with variation of light exposure

Algorithm	luminosity			
	0	1	2	3
LBPH	Accuracy(%)			
	78	76	73,33	71,33

From table II; LBPH has high dark skin face recognition accuracy at 78,6. This is satisfied result compared to the previous study of NIST. The results of this testing demonstrated that the image database is the important factor that affects accuracy. The reference database which contains covered possible faces with light variation can improve the LBPH accuracy

The second experiment in this section is the facial recognition accuracy test with facial light variation. the position of the face in the test set is only the frontal face. four types of facial luminosity (0,1,2,3) were tested in this experiment.

As shown in Table III, LBPH can process the variation in luminosity of the face with stable and high precision which is 78.00% in the case of environmental lighting, 71.30% in the case of environmental lighting. less enlightened environment. in Table III the results showed that LBPH has good precision in each experiment. The results of this research concern the A. zdils study (9) which reveals that LBPH is the most efficient facial recognition method.

C. Evaluations

The evaluation was done by manual verification. Humans have the ability to recognize and classify the face with a robust attitude to varying views of the face(10). Therefore, manual verification is very useful to control and verify the results of face detection and recognition, with greater efficiency in small experiments. Manual verification also allows us to consider the appearance of the image and categorize issues that may lead to false detection and recognition.

D. Discussions

The database is an important part of the facial recognition system. In this research, the selected method is to manually capture the student images and save the image. This process was performed in a controlled environment with variations of lights. The advantage of this method is that every factor depending on the requirements of the facial recognition system can be strictly controlled. However, this method has a downside because it takes a long time to collect the images.

As a result, facial lighting is a factor that can affect the accuracy of facial recognition. In the case of very good brightness, the accuracy of facial recognition is likely to be higher than normal. This may be because the color of the face is much less important than in other cases, so that a proportion of correct facial recognition is high.

LBPH is the algorithm achieved high precision in each experiment. The reason for this is that LBPH considers the regions of the images and converts them to a binary code to represent each image, so depicting the same person with a different facial appearance may reduce some facial detail. In addition, this method compares the input image to each image in the training set and analyzes them independently, so that an image database containing all the faces with the different possible brightness is able improve the accuracy of the LBPH. The recognition process compares the input images to the average of each subject, so that a variation in the brightness of the face may increase the risk of a face mismatch.



V. CONCLUSION

Facial recognition is a method of personal identification using biometrics that the process can be performed without the interaction of humans and devices. For this, facial recognition has been selected to be applied in an identity control and verification system. Since facial recognition systems are typically implemented in different locations in unconstrained environments, work has investigated factors that impact facial recognition accuracy. There are two factors that can affect the accuracy of the system; the color of the skin of the face and the brightness of the surroundings. In addition, this study aims to assess the accuracy of facial recognition of the well-known algorithms, namely LBPH. The experiments carried out in respect of the variation of the variation of luminosity. The results of the experiment demonstrated that LBPH has good accuracy which reaches 78.6% accuracy in tests based on still images. Therefore, LBPH is a suitable algorithm to apply in a dark skinned face control system.

This research can serve as a guide for those interested in the application of facial recognition in the real world system, in particular in terms of identity control and verification system in a sub-Saharan environment.

The system evaluation check showed that the algorithms are still not robust for a real world system and the processing speed is still low in the typical computer. Therefore, it is difficult to improve the accuracy of facial recognition for basic facial recognition algorithms such as like LBPH in the real world. Since these algorithms are easy to implement with the library provided in OpenCV, they are very useful for study and implement an effective facial recognition system for their needs.

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