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# A Study on Face Recognition Techniques using variants

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***Abstract:*** *Face recognition has been a fast growing, challenging and interesting area in real time applications. A large number of face recognition algorithms have been developed in last decades. In this paper an attempt is made to review a wide range of methods used for face recognition comprehensively. This paper deals with the topic of face recognition techniques using digital image processing. Face recognition has always been a very challenging task for the researches. On the one hand, its applications may be very useful for personal verification and recognition.*
***Index Terms:****Karhunen-Loève, eigenfaces, eigen values, line edge maps*

## I. INTRODUCTION

It has always been very difficult to implement due to all different situation that a human face can be found. Nevertheless, the approaches of the last decades have been determining for face recognition development. Due to the difficulty of the face recognition task, the number of techniques is large and diverse. In addition, the applications involve a huge number of situations.

Although we can find many other identification and verification techniques, the main motivation for face recognition is because it is considered a passive, no intrusive system to verify and identify people. There are many other types of identification such as password, PIN (personal identification number) or token systems. Moreover, it is nowadays very instilled the usage of fingerprints and iris as a physiological identification system. They are very useful when we need an active identification system; the fact that a person has to expose their body to some device makes people feel being scanned and identified. The pause-and- declare interaction is the best method for bank transactions and security areas; people feel conscious of it, as well as comfortable and safe with it. However, we do not want to interact with people that way in many other applications that required identification. For example, a store that wishes to recognize some customers or a house that has to identify people that live in there. For those application, face as well as voice verification are very desirable. It is also important that an identification technique is closer to the way human beings recognize each other.

As it has already said previously, the applications for face recognition are very varied. We can divide them into two big groups, the applications that required face identification and the ones that need face verification. The difference is that the first one uses a face to match with other one on a database; on the other hand, the verification technique tries to verify a human face from a given sample of that face.Face recognition could be also divided into two different groups, according to their field of application. The main reason for promoting this technique is law enforcement application; however, it can also be used for commercial application.

Concerning commercial applications we can differentiate between entertainment (video games, virtual reality and training programs), smart cards (driver's license, passport and voter registration) and information security (TV parental control, cell phone and database security).

It has already been stated that face recognition techniques have always been a very challenging task for researches because of all difficulties and limitations. Human faces are not an invariant characteristic; in fact, a person's face can change very much during short periods of time (from one day to another) and because of long periods of time (a difference of months or years). One problem of face recognition is the fact that different faces could seem very similar; therefore, a discrimination task is needed. On the other hand, when we analyze the same face, many characteristics may have changed. Ones of the most important problems are changes in illumination, variability in facial expressions, the presence of accessories (glasses, beards, etc); finally, the rotation of a face may change many facial characteristics.

## II. APPROACH

The paper principally deals with the comparison of two different methods for face recognition. These methods are *"Face Recognition Using Eigenfaces"* and *"Face recognition using line edge map"*.

For each of the techniques, a short description of how it accomplishes the described task will be given. Furthermore, some tables and results will be showed in order to understand the accuracy of each method. This report only shows a comparison of already made research studies; therefore, the pictures used and the data are extracted from the original sources. Since the methods do not follow a common line, they will be described separately; it is due to the different ways to achieve face recognition. We could divide face recognition techniques into two big groups: the ones that tackle the problem using geometric approach, and the ones that use feature-based characteristics.

Finally, a discussion about the best characteristics of each method will be carried out. Depending of the technique, and more important of the work performed to make the article, different situation of face position, lighting, etc will be commented. The main goal of this paper is find a good face recognition technique depending on the situation.

## III. WORK PERFORMED

During this section, the two face recognition algorithms will be explained in order to understand the basis of each one. They have been selected because two main reasons: they are very known and spread techniques for face recognition; moreover, they represent different ways to approach the problem as it was stated before. The first technique is based on the so- called Karhunen-Loève transformation using eigenfaces for recognition. The second one tries a new algorithm using line edge maps to improve the previous methods such as the eigenfaces.

**Face recognition using eigenfaces**

As a general view, this algorithm extracts the relevant information of an image and encodes it as efficiently as possible. For this purpose, a collection of images from the same person is evaluated in order to obtain the variation. Mathematically, the algorithm calculates the eigenvectors of the covariance matrix of the set of face images.

Each image from the set contribute to an eigenvector, these vectors characterize the variations between the images. When we represent these eigenvectors, we call it eigenfaces. Every face can be represented as a linear combination of the eigenfaces; however, we can reduce the number of eigenfaces to the ones with greater values, so we can make it more efficient.

**Face recognition using line edge map**

In addition, it proposes a line matching technique to make this task possible. In opposition with other algorithms, LEM uses physiologic features from human faces to solve the problem; it mainly uses mouth, nose and eyes as the most characteristic ones.

In order to measure the similarity of human faces the face images are firstly converted into gray-level pictures. The images are encoded into binary edge maps using Sobel edge detection algorithm. This system is very similar to the way human beings perceive other people faces as it was stated in many psychological studies. The main advantage of line edge maps is the low sensitiveness to illumination changes, because it is an intermediate-level image representation derived from low-level edge map representation. The algorithm has another important improvement, it is the low memory requirements because the kind of data used. There is an example of a face line edge map; it can be noticed that it keeps face features but in a very simplified level.

The main strength of this distance measurement is that measuring the parallel distance, we choose the minimum distance between edges. It helps when line edge is strongly detected and the other one not. It avoids shifting feature points. However, it also has a weakness; briefly, it can confuse lines and not detect similarities that should be detected. In order to avoid errors, another measurement can be made. We can add a new parameter to the Hausdorff distance, comparing the number of lines in the images is a good method to exclude images.

**Face recognition using eigenfaces results**

The eigenfaces algorithm used a database of 2500 face images taken from 16 subjects. Each subject was exposed to all combinations of three head orientations; moreover, a six level Gaussian pyramid was created so each image had resolutions from 512x512 to 16x16 pixels. Two different experiments were performed, the first one allowed an infinite value of the threshold. On the other hand, the second experiment varied this threshold in order to achieve conclusions about it.

During the first experiment no face was rejected as unknown because of the infinite threshold, statistics were collected measuring the mean accuracy as a function of the difference between the training conditions and the test conditions.[4] The results were a 96% of accuracy with illumination changes, 85% with orientation variation and a 64% when the sized changed. The second experiment tried both a low threshold and a high one in order to compare the accuracy of recognition and the rejected images. With a low value , many images were rejected because they were considered not belonging to the database; however, a high correct classification percentage was achieved. On the other hand, using a high value, the great majority of images were accepted but the errors increased. Finally, adjusting the threshold to obtain a 100% of recognitions, the unknown rates were 19% for lighting variations, 39% for orientation and 60% for size.

**Face recognition using line edge map results**

The images for the experiments belong to three different databases, University of Bern for pose variations, the AR database from Purdue University was used to evaluate the algorithm with illumination and size variations, The Yale face database had the purpose of compare the algorithm with other methods. The experiments were performed using three different algorithms: the edge map, the eigenfaces and LEM. Therefore, tables with a comparison of the algorithms are provided.

Tables with the corresponding results are shown in order to make a good comparison with the other algorithm discussed in this paper. The results show probabilities of correct detection of the different algorithms and some experiments include variation of parameters such as number eigenvectors or light direction.Each table is labeled so its content can be understood. Not all the results from the article are showed in this paper, but it has the necessary to make a good comparison of the general characteristics of the algorithm.

| | Bern database | | | AR database | | |
|---|---|---|---|---|---|---|
| Method | EM | Eigenface | LEM | EM | Eigenface | LEM |
| Recognition rate | 96.7% | 100% | 100% | 88.4% | 55.4% | 96.4% |

**Table 1: Results for size variations for edge map, eigenface (20 eigenvectors) and LEM.**

| Method | Recognition rate |
|---|---|
| LEM | 96.43% |
| Eigenface (20-eigenvectors) | 55.36% |
| Eigenface (60-eigenvectors) | 71.43% |
| Eigenface (112-eigenvectors) | 78.57% |

**Table 2: Comparison of LEM and eigenfaces methods with the AR database images**

| Testing faces | Eigenface | | Edge map | LEM |
|---|---|---|---|---|
| Left light on | 20-eigenvectors | 6.25% | 82.14% | 92.86% |
| | 60-eigenvectors | 9.82% | | |
| | 112-eigenvectors | 9.82% | | |
| | 112-eigenvectors w/o 1st 3 | 26.79% | | |
| Right light on | 20-eigenvectors | 4.46% | 73.21% | 91.07% |
| | 60-eigenvectors | 7.14% | | |
| | 112-eigenvectors | 7.14% | | |
| | 112-eigenvectors w/o 1st 3 | 49.11% | | |
| Both lights on | 20-eigenvectors | 1.79% | 54.46% | 74.11% |
| | 60-eigenvectors | 2.68% | | |
| | 112-eigenvectors | 2.68% | | |
| | 112-eigenvectors w/o 1st 3 | 64.29% | | |

**Table 3: Results for lightning variation for three algorithms**

| | Recognition rate | | | |
|---|---|---|---|---|
| Method | Edge map | Eigenface (20-eigenvectors) | Eigenface (30-eigenvectors) | LEM |
| Looks left/right | 50.00% | 70.00% | 75.00% | 74.17% |
| Looks up | 65.00% | 51.67% | 56.67% | 70.00% |
| Looks down | 67.67% | 45.00% | 55.00% | 70.00% |
| **Average** | **58.17%** | **59.17%** | **65.12%** | **72.09%** |

**Table 4: Results for the three algorithms and different face poses**

## IV. RESULTS

Since the objective of this paper is not the implementation of the algorithms, but the description and comparison of them, the results will be reported from the experiments performed by the authors of the articles. Both methods were tested using variations of face orientation, illumination and size.

## V. CONCLUSION

The main reason is that the results of the eigenfaces method do not describe the exact procedure; therefore, the reported results will not be as reliable as expected. Other reason is that an article that tries to demonstrate that LEM algorithm is better than others.

The first conclusion that can be said from the results of the eigenfaces algorithm is related to the threshold to determine a match in the input image. It was demonstrated that the accuracy of recognition could achieve perfect recognition; however, the quantity of image rejected as unknown increases. The dependence of accuracy and features changing is other characteristic to take into account. The results show that there is not very much changes with lighting variations; whereas size changes make accuracy fall very quickly. In order to avoid the most important weakness a multiscale approach should be added to the algorithm.

As it was predicted, for lighting variations the LEM algorithm kept high levels of correct recognitions. In addition, LEM method always managed the highest accuracy compared with eigenfaces and edge map. The disagreement between two articles about the results of eigenfaces with lighting variations could be due to a matter of concept.

LEM algorithm demonstrated a better accuracy than the eigenfaces methods with size variations. While eigenfaces difficultly achieved an acceptable accuracy, LEM manage to obtain percentages around 90%, something very good for a face recognition algorithm. Finally, taking into account the results for orientation changes, LEM algorithm could not beat eigenfaces method. LEM hardly reach a 70% for all different poses.

As a general conclusion, it could be said that LEM, as a more recent research; allows better results for lighting and size variations. More concretely, it beats eigenfaces method with size variation; where it has its most important weakness. On the other hand, eigenfaces algorithm demonstrated better results for posing changes than LEM, possibly because of the basis of the algorithm. LEM is based on face features, while eigenfaces uses correlation and eigenvector to do so.

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