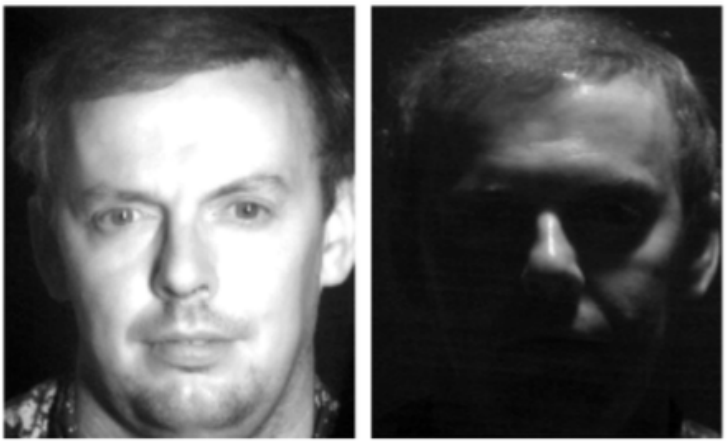
Review report on “Eigenfaces vs. Fisherfaces: Recognition Using Class Specific Linear Projection”.

Introduction

Content

The research is concerning a face recognition algorithm which is unaffected by light direction and the great changes of facial expression and this algorithm is called Fisherfaces. The Fisherfaces method utilizes class specific linear projections for identification (Belhumeur, Hespanha & Kriegman, 1997). Meanwhile, Fisher’s Linear Discriminant (FLD) is the fundament of projection approach, even in the case of serious alterations in illumination and facial expression, it could generate great separation classes in low-dimensional subspace (Belhumeur, Hespanha & Kriegman, 1997). If the face is a Lambertian surface without shadowing, a pattern classification method is adopted to treat each pixel in the image as a coordinate in the high-dimensional space, also the image of a specific face is located in a three-dimensional linear subspace in the high-dimensional image space under different lighting but constant posture (Belhumeur, Hespanha & Kriegman, 1997). Nevertheless, because faces are not real Lambertian surfaces and do arise from shadows. As a result, instead of modeling this bias specifically, it is better to project the image linearly into a subspace in a way that discounted the face region with the great bias in order to the image will not deviate from this linear subspace

(Belhumeur, Hespanha & Kriegman, 1997). Moreover, although there are lots of face recognition algorithms have been proposed and great progress has been made in recognizing faces with small alterations in light, facial expression and posture, the reliable techniques for recognizing faces with more extreme changes have proved difficult to implement (Belhumeur, Hespanha & Kriegman, 1997). Another challenge that faces recognition technology should face and settle is when the light source shines on the face of the same person from different directions, though it is the same person, the same facial expression and from the same perspective, it is will appear significantly different (Belhumeur, Hespanha & Kriegman, 1997). This is shown below that the same person will be significantly different under different lighting conditions like the main light source is almost positive in the left picture, yet the main light source is from top to right in the right picture (Belhumeur, Hespanha & Kriegman, 1997).



Therefore, proposing a new algorithm for face recognition is very important. However, other problems still wait for solving. For instance, how far the Fisherface approach extends to a large database and if the observation of some

individuals under only one illumination condition, whether can lighting conditions be adjusted or not (Belhumeur, Hespanha & Kriegman, 1997).

Innovation

The research identifies the challenges of face recognition which is difficult to achieve a reliable technology for face recognition under excessive changes. At the same time, the variational illumination influences the face recognition technology and the intensity, direction and quantity of the light source all contained in the variability of lighting and there are obvious deviations of the image because of the different direction of light source (Belhumeur, Hespanha & Kriegman, 1997). As a consequence, the research pointing out the creative idea is a new method to face recognition which is insensitive to extreme alterations in lighting and facial expression (Belhumeur, Hespanha & Kriegman, 1997). This research clarifies four different approaches of face recognition algorithm to solve problems and make a deep comparison between these methods which have become very popular in the face recognition literature. Subsequently, these approaches are Correlation, Eigenfaces, Linear Subspaces and Fisherfaces respectively (Belhumeur, Hespanha & Kriegman, 1997). Meanwhile, the face database of Harvard and Yale are applied by the research to test these methods and to prove Fisherface that the is developed by the research has more benefits than other approaches. First of all, the

routine of Correlation could be summarized as allocating the label of the nearest points in learning set to the image of testing set so as to identify the image in testing set. If the unit variance is zero following by normalizing to mean of all images, it means choosing the most relevant testing image in learning set (Belhumeur, Hespanha & Kriegman, 1997). However, there are three defects which list in the research. The first one is pointed in the image space that may not stay together closely because of collecting the images of the learning set and the testing set under diverse illumination conditions. Subsequently, it is expensive to compute in logical relationship and it also needs a lot of storage because a large amount of images of each person have to include in the learning set (Belhumeur, Hespanha & Kriegman, 1997). Secondly, the research introduces the Eigenfaces method which is using principal components analysis (PCA) technology. This technology in order to let the scatter of all projected samples become maximize, so it is necessary to select a dimensionality decreasing linear projection (Belhumeur, Hespanha & Kriegman, 1997). The disadvantage of this method is its dispersion, maximization is not just owing to between-class scatter and it is applicable to classification as well as within-class scatter (Belhumeur, Hespanha & Kriegman, 1997). Thirdly, the research states the third method linear subspaces which could be considered as calculating the distance from a new image to each line subspace, in addition, select the face that corresponds to the shortest distance (Belhumeur, Hespanha & Kriegman, 1997). Furthermore, linear subspace method could

accomplish error-free under any lighting conditions if there is no noise and shadow. Whereas, some areas in the face image contain variability that does not suitable for the linear subspace. Then it is necessary to measure distance between each person to the line subspace so as to identify the test image. Furthermore, three images are needed in memory for each person for the linear subspace approach. As a result, it still exists some problems and shortcomings (Belhumeur, Hespanha & Kriegman, 1997). Finally, because of the problems of these methods mentioned above for face recognition, the research discusses Fisherface method will obtain better recognition rate if it compares with linear subspace or Eigenface approach, owing to it uses easy classifier in dimensionality reduction space and class specific linear dimensionality reduction method. The Fisher's Linear Discriminant tries to allow the ratio of between-class scatter to within-class scatter reached the maximum (Belhumeur, Hespanha & Kriegman, 1997). The expression of between-class scatter and within-class scatter can be shown as below:

$$S_B = \sum_{i=1}^{c} N_i(\boldsymbol{\mu}_i - \boldsymbol{\mu})(\boldsymbol{\mu}_i - \boldsymbol{\mu})^T$$

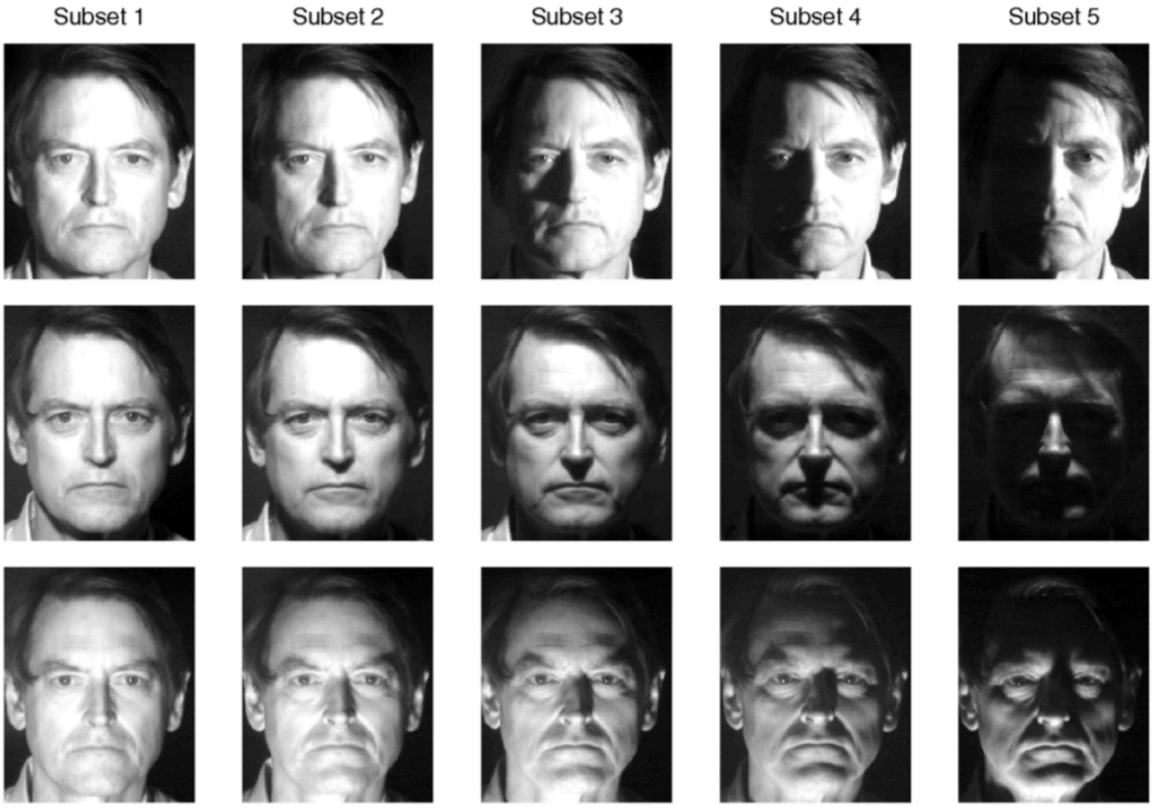
between-class scatter

$$S_W = \sum_{i=1}^{c} \sum_{\mathbf{x}_k \in X_i} (\mathbf{x}_k - \boldsymbol{\mu}_i)(\mathbf{x}_k - \boldsymbol{\mu}_i)^T$$

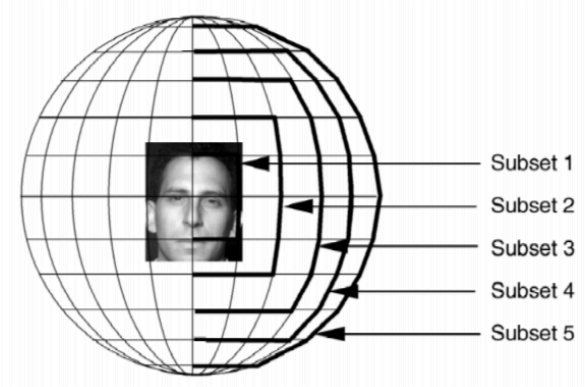
within-class scatter

Technical Quality

The research lists the experiments under three different hypothesizes in order to test performances of these four algorithms and the research uses two varying databases to support their perspectives (Belhumeur, Hespanha & Kriegman, 1997). Consequently, the technical development shows the high quality in this research because of enough experiments except the last experiment. Firstly, the alteration of lighting becomes the first hypothesizes that they need to verify. In details, the research uses the image database of Harvard robotics laboratory to verify and compare the ratio of error of these four methods that are mentioned above (Belhumeur, Hespanha & Kriegman, 1997). They use 330 photos in which 66 photos each of five different people and the subjects would maintain their head stability when illuminated by the main light source in each image in this database (Belhumeur, Hespanha & Kriegman, 1997). The sample of subsets is shown in the following picture.



After that, the lighting source direction space is then sampled in the amount of growth of 15$, which could be parameterized by spherical angles and it displays below (Belhumeur, Hespanha & Kriegman, 1997).



The extrapolation and interpolation experiments are tested based on the Harvard database. Therefore, the research gains some conclusions from these experiments and the most significant theory is comparing to Eigenface method, Fisherface approach needs less calculation time and owns lower error rates (Belhumeur, Hespanha & Kriegman, 1997). The second hypothesize which they need to illustrate to support their theory is the change of facial expression, eye wear and illumination (Belhumeur, Hespanha & Kriegman, 1997). They design experiment to determine the comparison of these approaches under diverse conditions for using a second database which is created by the computing vision and control center of Yale. Ten images were obtained in one process for 16 subjects that contain both male and female and they all in an easy background. Meanwhile, some of them with glasses and beards and the following photo shows one subject (Belhumeur, Hespanha & Kriegman, 1997).

The research describes in detail how they did the test and how they compared

the performance of these four methods in the experiment. In addition, the linear subspace algorithm performs better in pervious experiment even than this experiment (Belhumeur, Hespanha & Kriegman, 1997). There is one interesting finding that found from this experiment, the performance of all the approaches gain better results. Furthermore, Fisherface approach has enhanced greatly, with the error rate dropping from 7.3% to 0.6% (Belhumeur, Hespanha & Kriegman, 1997). Finally, the last hypothesis is about the identification of glasses. The data set included 36 images from the Yale database in this test which the half subjects were bespectacled and the recognition rate is gained through cross validation and the error rate of these two algorithms are showed in the following table (Belhumeur, Hespanha & Kriegman, 1997).

Glasses Recognition		
Method	Reduced Space	Error Rate (%)
PCA	10	52.6
Fisherface	1	5.3

Application and X-factor

From this research, I have an understanding of four diverse face recognition approaches and the challenges in the face recognition. I finding the Fisherface which has been proposed by the research is appropriate for the future application and could solve the problems of face recognition, even there are still some problems are exits under extensive experiments. From this research, they only compare these four methods between two official database and sometimes they could try to do more experiments for using more reliable databases to test the Fisherface that they have been proposed to settle the problems. Moreover, they could continue to test the performance of Fisherface under more different hypothesizes to ensure the Fisherface method performs the best and could implement in the future. In addition, they also should solve the problems that they left behind and try to improve the existing technology to make it better and more widely used in the future.

Presentation

After reading this research, I think the quality of this research is relatively high. The whole research was separated by four main parts which are the introduction of the method that will proposed, the introduction of other three approaches that make a comparison with Fisherface, the experiments that they made to support their theory and final summary. I found it is easy to follow the theories of author and the paper is relative logical for reader to understand. Furthermore, there were some graphs provided to support their opinions and offered the clear evidences to help readers to understand what they were talking about in this research. However, if they offer some real application in the socieity of the method, it could be more attractive for the readers.

References

Belhumeur, P., Hespanha, J. and Kriegman, D. (1997). Eigenfaces vs. Fisherfaces: recognition using class specific linear projection. IEEE Transactions on Pattern Analysis and Machine Intelligence, 19(7), pp.711-720.