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# Expressions Invarient Face Recognition

S. ULLAH[++], N. AHMAD, K. AHMAD, S. R. HASSNAIN[*]

Department of Computer Systems Engineering, University of Engineering and Technology, Peshawar

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**Abstract:** Variation of Facial expression is one of the most challenging factors in face recognition which significantly degrades the performance of the face recognition system. This paper presents a mechanism for reducing the high false positive rate in face recognition due to facial expression by using a novel Gaussian blurring and decimation algorithms. Extensive experimentation on complex images with variant facial expressions from the ORL dataset shows that removing the higher frequencies in the pre-processing step enhances the performance of eigenfaces algorithm by a significant amount i.e. from 93.75% to 96.5%.

**Keywords***:* Face Recognition, PCA, Eigen-faces, Decimation, Facial Expressions

## 1. INTRODUCTION

Vision based face recognition has remained a popular and productive research area for the last two decades (Moses *et al.,* 1994). Being a prominent feature of person identification, determining the health conditions and emotional tendencies, retrieving other social information and a wide range of other applications such as security, criminal identification, credit card verification, currency identification and patient care systems, makes face recognition as an area of keen interest for computer science researchers as well as neuroscientists and psychologists. Due to complicated and dynamic nature, the vision based face recognition is suffering with a number of challenges like changes due to age factor, expressions, presence or absence of structure components, resolution, occlusion, pose and variation in lightening conditions under which the images are taken and variation in viewing conditions (Moses *et al.,* 1994). These challenges are discussed in greater details in (Min-Hsuan and Narenda, 2002).

According to Min-Hsuan (Min-Hsuan and Narenda, 2002) the vision based face recognition approaches can be categorized in four categories including: features, appearance, knowledge and template based approaches. The rule/knowledge based approaches rely on rules based on the human perception/knowledge about the structure of human face e.g. presented by Yang and Haung (Yang and Haung, 1994). The biggest issue with rule-based approaches is the formulation of rules from the human knowledge about faces; especially in cluttered and rotated images it becomes really difficult to detect human face. The template based approaches utilize the stored patterns/structures known as templates for detection/recognition purposes (e.g. presented by Sakai *et al.,* 1969).

Although multi-scale and multi-resolution templates have been introduced to tackle with scaling and resolution issues but still variation in viewpoint, lighting conditions, scale and resolutions are among the most threatening challenges to template based approaches. To overcome the invariances problems, the feature based approaches utilize the invariant features like skin color (Chai and Ngan, 1998) and texture (Marijke and Skujca, 1993).

The appearance based approaches develop a model of human face's structure from the training images for detection/recognition purposes through statistical analysis and machine learning algorithms. Eigenfaces based face detection by Turk and Pentland (Mathew, Turk and Pentaland, 1991) is one of the most important representatives of appearance based face recognition approaches. Despite of being state-of-the art approach, eigenfaces based approach suffers from variation in lighting conditions, scale and facial expressions. (Wang *et al.,* 2006) worked out the facial expressions problem in face recognition in greater details.

The main contribution of this work is in the pre-processing step where two different algorithms including: the low pass filtering and Decimation have been introduced. The basic goal of the pre-processing step is to eliminate the higher frequencies which contain the pose and facial expressions like information.

The rest of paper is organized in five sections including: the literature review followed by a brief introduction to eigenfaces based face recognition, low pass filtering and decimation. Section IV and V represent the methodology and the experimentation and

[++]Corresponding Author: S. Ullah, shakir702@yahoo.com, Ph. No +92-91-9216590

*Department of Electronics Engineering, University of Engineering and Technology, Peshawar (Abbotabad Campus), Pakistan

analysis steps respectively, while section VI summarizes the conclusions from this work.

## 2. MATERIALS AND METHODS

Literature Review

Research on face recognition dates back to 1965, the Pioneers of automatic face recognition W. Bledsoe, H. Chan Wolf and C. Bisson worked out the computer vision based face recognition for the first time (Makeshwar *et al.,* 2010). Beldose used the normalized distances and ratio of fiducial marks among different points such as eyes, nose, and mouth corners as features for his semi-automatic face recognition system.

In early 1970s, (Goldstein *et al.,* Goldstein *et al.,* 1971) introduced a 21 featured classification technique for human faces recognition. Along with 21 features they utilized the spatial information. Fischler and Elschlager (Fischler and Elschlager, 1973) too worked out the featured based face classification approach with local features template matching and global ration of fit find. They developed a global template of face by combining the local (hair, eyes, mouth, nose and left right edges) ration of fit find through springs.

Some of the approaches utilize the neural network with different learning algorithms based solution to face recognition e.g. presented by Latha *et al.,* (Latha *et al.,* 1971), where the Principal Component Analysis algorithm for dimensionality reduction and neural network algorithm are used along with some pre-processing for noise reduction and image transformation for extraction of certain features. For the evaluation of the said approach they used Yele dataset with two performances measuring metrics: acceptance ratio and execution time and claimed for 90% accuracy. The neural network based approach introduced by Turk and Pentland (Mathew, Turk and Pentaland, 1991) initially tracks the human head in a scene and recognize it through the neural network algorithm by considering it as two dimensional problems with the learning and recognition advantages in an un-supervised manner.

Agarwal *et al.,* (Agarwal *et al.,* 2001) introduced the concept of coding and decoding of information theory for face recognition in two steps of features extraction and recognition. They used PCA and feed forward back propagation approaches for feature extraction and recognition respectively. Performance of proposed technique is evaluated on 400 categories of objects from a state-of-art dataset: Olivetti and oracle Research Laboratory (ORL) of face recognition. The author claimed for 97.018% recognition rate.

Baocai *et al.,* (Baocai *et al.,* 1998) represented an extension of Fisherface approach with Morph able model to generate multiple images of a single image. The inclusion of Morph able model tackled the unavailability of multiple example images per person. They used region filling and hidden surface removal methods for the generation of virtual example images.

Kim (Kam, 2008) used the Principal Component Analysis for the dimensionality reduction by expressing the large 1-D vector containing the pixels of Turk and Pentaland's 2-D facial image compact principal components (Eigen-space). In this paper the authors highlighted classification capabilities of PCA with low dimensionality. Although the recognition performance of this approach on the test data was quiet acceptable but the author did not recommend it for real time applications.

**Overview of Algorithms Used**

*Eigen Faces*

The Eigen Faces approach is a representative of appearance based approach to face recognition and aims to utilize the variation based information for encoding and comparison of individual faces in holistic/rounded manner, and reveals the information about the contribution of local and global features in face representation. The concept of Eigen face was first introduced by Sirvoich and Kirby in 1987 for the low dimensional representation of face images. Later on, Turk and Pentaland utilized it for face recognition (Mathew, Turk and Pentaland, 1991). The Eigen faces are basically a collection of eigenvectors (set of features extracted from the covariance matrix of probability distribution with the help of Principal Component Analysis). The resultant low dimensional images termed as Eigen pictures are used for the reconstruction of original training images. The number of Eigen pictures is always less than the number of images in training set.

*Decimation*

Image decimation is the process of reducing the image resolution by kicking out the unnecessary information without affecting the image quality. In decimation, image is scanned line by line removing the redundant pixel and computing the average of pixels groups equal to the average of pairs\groups of pixels. Keeping equal the average of the newly formed groups of pixels with the original groups ensures that the newly formed image is a mirror image of the original but reduced in size. The big advantage of decimation is that it reduces the execution time by a significant amount without much effecting the image quality but here in face recognition it along with low pass filter serves another function of removing the facial expressions leaving the face structure unchanged. Decimation can be carried out at different levels however the nature of application determines which level of decimation is sufficient.

*Gaussian Blurring (Low Pass Filter)*

Gaussian blurring is used to remove the higher frequencies in a pattern. It is used in pre-processing step for the removal of unwanted information in an image. Gaussian blurring can be achieved by convolving the input image with the Gaussian operator as given in eq. 1. The Gaussian operator is just like the mean filter but with different kernels representing the Gaussian i.e. bell shape). In this work the Gaussian filter is used to remove the facial expression information which causes the problems in face recognition.

$$G(x,y) = \frac{1}{2\pi\sigma^2}\, e^{-\frac{x^2+y^2}{2\sigma^2}} \qquad (1)$$

DATA SET

For the assessment of the proposed solution to the facial expression problem is carried out on 400 images from a standard dataset of face recognition called Olivetti and oracle Research Laboratory (ORL). The dataset contains images with facial expressions and pose changes as well as images with variation in scale and source of illumination. **(Fig. 1)** shows some sample from the ORL dataset.

**Fig. 1 Sample Image from ORL Dataset**

**Methodology**

**(Fig. 2)** represents the block diagram of the proposed methodology adopted in this work. As stated earlier, this paper is concerned with the pre-processing only, so two steps i.e. 2nd and 3rd steps are of main interest here. Decimation is used to remove the un-necessary information from the image; As in this case we are concerned with face recognition only, so the pose information and facial expressions are irrelevant information in this case which are removed in decimation process. Decimation is used with two different factors 2 and 4.

In the next step, low pass Gaussian filter is used for reduction of noise and other irrelevant information in higher frequencies. The fspecial function is used for the implementation of Gaussian low pass filter with different values of its parameter i.e. sigma (standard deviation) and hsize (window size). Next, features are extracted from the images and ensembled using PCA (principle component analysis) to create the face sub space.

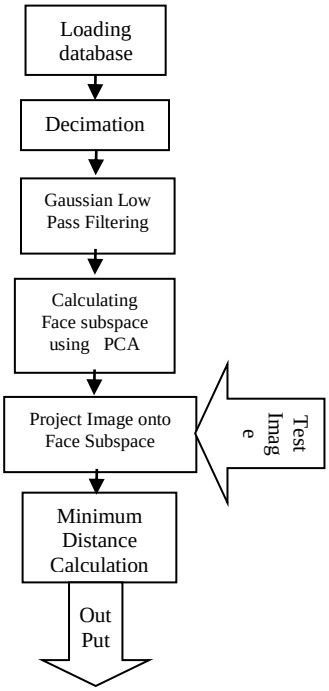


**Fig. 2: Methodology used in this work**

## 3. RESULTS AND DISCUSSION

As this work aims to tackle the high false positive rate in face recognition due to facial expressions, so for the evaluation of the proposed work complex images with expressions are selected from ORL dataset.

**(Table 1)** represents the results of the original implementation of eigen faces algorithm, while Table 2 and Table 3 show the results of eigen face algorithm with pre-processing with low pass filtering with different window sizes and standard deviation, and decimation by factor 4 and 2 respectively for different feature vectors.

**Table 1. Experimental results without pre-processing step on 400 test images.**

| Feature Vector | Percentage |
|---|---|
| 10 | 91.5% |
| 15 | 92.75% |
| 20 | 93% |
| 25 | 93% |
| 30 | 93.5% |
| 40 | 93.5% |
| 60 | 93.75% |

The standard deviation, window size and decimation factor play very important role in removal of facial expressions as this information lies in the high frequencies. Keeping the standard deviation high will removes the facial expression as well as the face structure information and keeping it very low will not be sufficient to remove the facial expressions, so it must

be selected with proper care. Similar case is with the decimation factor and window size. Decimation by a higher factor may adversely affect the performance of the algorithm and a low value might not be sufficient to remove the irrelevant information. The window size also affects the performance of the algorithm as clear from **(Table 2 and Table 3).**

**Table 2. Results with pre-processing: decimation by factor 4 and low pass filtering with different window sizes and standard deviation on 400 test images**

| Feature Vector | Hsize= 6, σ=3 | Hsize= 6, σ=4 | Hsize= 6, σ=5 | Hsize= 5, σ=3 | Hsize= 5, σ=4 | Hsize= 5, σ=5 |
|---|---|---|---|---|---|---|
| 10 | 93.5% | 93.75% | 93.75% | 93% | 93.5% | 93.5% |
| 15 | 95.25% | 95.25% | 95% | 95% | 95% | 95% |
| 20 | 94.25% | 94.25% | 94.25% | 95.5% | 95.25% | 95.25% |
| 25 | 95.55% | 95% | 95.25% | 95.75% | 95.75% | 95.75% |
| 30 | 96.5% | 96.25% | 96.5% | 95.5% | 95.25 | 95.5% |
| 40 | 93.75% | 94% | 93.75% | 93.75% | 94.25% | 94% |
| 60 | 93.5% | 93.75% | 93.75% | 93% | 93.5% | 93.5% |

**Table 3. Results with pre-processing: decimation by factor 2 and low pass filtering with different window sizes and standard deviation on 400 test images**

| Feature Vector | Hsize=6, σ=3 | Hsize=6 , σ=4 | Hsize=6, σ=5 | Hsize=5, σ=3 | Hsize=5, σ=4 | Hsize=5, σ=5 |
|---|---|---|---|---|---|---|
| 10 | 94% | 94% | 94% | 93.5% | 93.5% | 93.5% |
| 15 | 93.5% | 93.25% | 93.25% | 93.5% | 93.5% | 93.5% |
| 20 | 95.5% | 95.5% | 95.5% | 95.25% | 95.25% | 95.25% |
| 25 | 95% | 95% | 95.25% | 94.75% | 94.75% | 94.5% |
| 30 | 95% | 95% | 95% | 95.5% | 95.5% | 95.255 |
| 40 | 94.25% | 94% | 94% | 95% | 95% | 95% |
| 60 | 94% | 94% | 94% | 93.5% | 93.5% | 93.5% |

## 4. CONCLUSION

The facial expressions cause severe problems in face recognition which is addressed by this work in pre-processing step with low pass filtering and decimation. From the experimental results it can be concluded that using the low pass filtering and decimation by a proper factor significantly improves the performance of face recognition algorithm in face images with expressions.

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