Face Identification based on Biological Trait using Infrared Images after Cold Effect Enhancement and Sunglasses Filtering

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ABSTRACT

This paper describes face identification using infrared images and eigenfaces after passing test face through cold effect enhancement and/or sunglasses filtering algorithms and handling facial hair through threshold. Eigenface technique after modification is used to define our eigenspace. Test image before going through the recognition process has to pass through a check to see whether it is a face image or not. The test face is passed through an algorithm to check and enhance if the person come from cold and then is projected to eigenspace to find the match. If match is not found then it is passed through another algorithm to check whether person has worn sunglasses and if so the image is enhanced in order to make recognition more efficient. Only one person of the test sets is recognized wrongly with the other but both of them belongs to the training set and it gives 100% accurate results for profile images.

Keywords

Cold effect enhancement, Infrared images, Principle Component Analysis, Sunglasses filtering, Threshold.

1. INTRODUCTION

Principle Component Analysis is one of the most successful techniques for face recognition and dimension reduction [Ros96a]. This technique is also known as eigenfaces.

Infrared images represent the heat pattern emitted from an object. Since the vein and tissue structure of a face is unique, the infrared images should also be unique [Ros96a]. In eigenface technique, we have training and test set of images. Eigenvectors of covariance matrix of the training set of images are computed. The eigenfaces are also computed as described by Turk M. and Pentland [Pen 91a] but with some modifications.

When a test image come for recognition, it is checked whether this is a face or not, in order to reduce the false acceptance rate because a non-face image after enhancement can gain some features of face, then we pass it to the cold enhancement algorithm. The algorithm checks whether person has come from cold or not by checking pixel values at nose and cheeks. If the number of values is greater than the threshold then the selected area of face is enhanced and this selection is done by the algorithm itself and it enhances the values of pixels in the selected area. The test image is projected into the eigenspace and if it is below the specified upper threshold then the test image is of an authorized person. If the test image is not in the database then it passes through the sunglasses filtering algorithm and this algorithm checks whether a person whose image is taken wear glasses or not. If the number of values is greater than the threshold, the glasses area is enhanced and the pixel values are replaced with the nose tip pixel value. Again it is projected to eigenspace and if the error is below the specified threshold then the face is of an authorized person.

2. TRAINING SET TO DEFINE EIGENSPACE

The Training set can contain any number of images greater than one because eigenvector can not be zero. To support recognition of different expression of same face, the training set contains equal number of expressions for all subjects. Our training set contains the same number of images for every subject but the expressions may vary for different subjects. For example, there is a smiley image for one subject and other subject contains an angry expression image. Training set cannot contain an image for subject wearing sunglasses because it leads to a very high False Acceptance Rate.

3. PRINCIPAL COMPONENT ANALYSIS

Consider face images of size n x n. Those images can be thought of as a vector of dimension n^2, therefore the training set of images corresponds to a set of points in the high dimensional space. Since the facial images are similar in structure and can be described by lower dimensional subspace. We get the basic vectors each of length n^2 through Principal Component Analysis.

Let I_1, I_2, ..., I_N be images of the training set then mean image is calculated by

$$MI = (\Sigma_{j=1\ldots N} Ij)/N$$

Where N is the total no of images.

The mean deviation is calculated through

$$Xj = Ij\text{-}MI$$

Mean deviation is also called normalized face-vector and written as.

$$\Phi = [X_1\ X_2 \ldots X_N]$$

The covariance matrix is

$$C = (\Phi.\Phi^{-}) / N$$

Having dimension $n^2 \text{ X } n^2$.

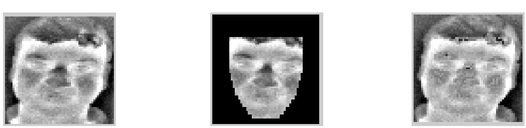
Calculating eigenvectors of C for size n^2 by n^2 is intractable so we determine the eigenvectors by solving an N x N matrix instead [Pen91b] & [Fuk90a]. Highest corresponding M eigenvectors are chosen to span an M-dimensional subspace. We project a test image onto eigenspace using following operations

$$w_i = u_i^{-} \text{ x (TestImage-MI), } i=1, 2, \ldots, M$$

Where w_i are the weights and forms a vector $[w_1\ w_2\ w_3 \ldots w_M]$, each weight shows the contribution of each Eigenface in representing the test face image [Ros96a] and u_i are the i highest eigenvectors corresponding to i highest eigenvalues.

4. COLD EFFECT ENHANCEMENT ALGORITHM

When person coming from cold stands in front of infrared camera, it catches this impact. This image will be different from the normal image. Hence it needs to be enhanced before recognition process.



(a) (b) (c)

Figure 1. Result after passing through cold enhancement algorithm

To overcome this problem, we check the nose and cheeks to see whether person comes from cold or not. If it attains a value greater than a specified threshold then selected area of the face is enhanced and the values in that area are normalized (See Fig.1). The image in Fig. 1(a) is the actual image came for enhancement and Fig. 1(b) shows the selection area and Fig. 1(c) shows the image after enhancement. For Internal working of algorithm (See Fig.2).

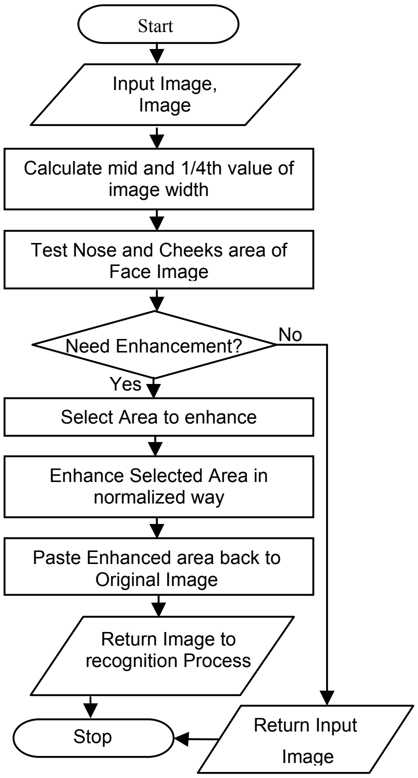


Figure 2. Working of Cold Effect Enhancement Algorithm

5. SUNGLASSES FILTERING ALGORITM

The image in this case will have very small pixel values and the area of sunglasses in the image will appear black. This algorithm checks whether there are sunglasses or not and if found then it replaces the sunglasses with the nose tip pixel value in order to normalize it.

(a) (b)

Figure 3. Result after passing through sunglasses filtering algorithm

The nose tip pixel is chosen because it is the part of the face first affected by the cold so that it should not assign a value to the area of sunglasses that will increase the False Acceptance Rate. We cannot make eyes of that person because it may lead to False Acceptance.

Fig.3 (a) is the original image came for recognition and Fig.3 (b) is the image after enhancement. For internal working of algorithm (See Fig. 4).

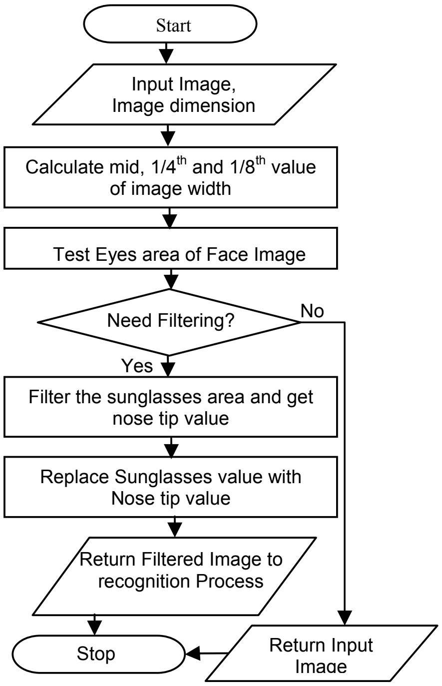


Figure 4. Working of Sunglasses Filtering Algorithm

6. RESULTS

Our training sets consist of 8 subjects having 9 expressions each that makes total of 72 images. Sample infrared images, Mean Image, Graph of Eigenvalues and Principal components are shown in Fig.5, Fig.6, Fig.7 and Fig. 8.

(a) (b) (c) (d)

Figure 5. Sample infrared images from the training set of 72 images

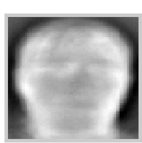


Figure 6. Mean image of 72 images

Graph of eigenvalues vs numbers of eigenvalues show the selection of 36 eigenvectors corresponding to 36 highest eigenvalues to define our eigenspace.

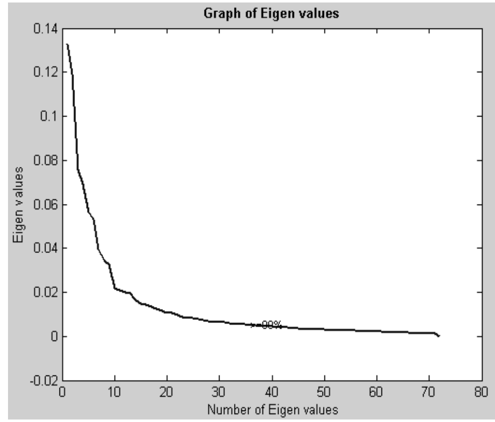
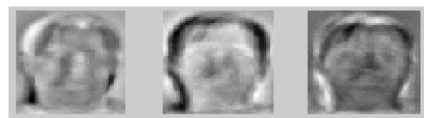


Figure 7. Graph of Eigenvalues vs Number of Eigenvalues



(a) (b) (c)

Figure 8. First three Principal components

Our test set contains the images of the subjects having different expressions used in our training set and image of persons that are not in our training set (See Fig. 9).

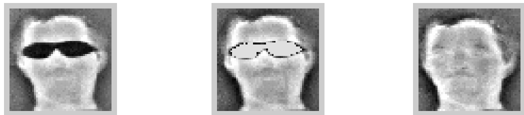
(a) (b) (c) (d)

Figure 9. Sample images from the test set

Fig.10, Fig.11, Fig.12 and Fig.13 shows the results obtained after projecting test images from the test set to eigenspace.

Figure 10. Not a face

Figure 11. Not in the database



(a) (b) (c)

Figure 12. Match is found

Only one face is recognized wrongly with other but both the persons belong to the training set (See Fig. 13). Fig.13 (a) wrongly matches with the Fig.13 (b) but both persons belong to our training set. The right side image is a reconstructed image

(a) (b)

Figure 13. Result of the test image

The reconstructed image is blur because of the selection of almost half highest corresponding eigenvectors.

Rose Cutler has used 2 expressions (normal and smiley) in the training set [Ros96a] where as we have used 9 expressions to implement our algorithms. Accuracy obtained by Rose Cutler was 96.6% where as our approach has shown accuracy of 99%.

7. CONCLUSION

The results show that our algorithms for cold effect enhancement and sunglasses filtering works quite well and do not lead to a false acceptance. These algorithms are developed to use in the security systems but they can be used in recognizing the person in public places and can help to pick the required person by the police. The Future work will involve the automated alignment of the face. The higher resolution images can produce better results. Our algorithm of PCA can be extended to motion detection and object recognition.

8. REFERENCES

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