Improved Eigenface Recognition using Hierarchical Technique

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Abstract

Face recognition is one of the important fields of computer vision and pattern recognition because of its applications in security and intelligence systems. In this paper we improve one of the famous algorithms used for face recognition which is Eigenface technique. The method of improvement used in this paper is the Hierarchical technique which means that input image will be applied into different levels of recognition instead of only one level as used in the regular Eigenface method. The hierarchical technique developed in this paper increases the detection rate in the case of large benchmark image database by more than 30% as compared to the original method.

Eigenface Recognition Technique

The Eigenface technique for face recognition is based on the Principal Component Analysis (PCA) method which is based on constructing a new bases for the given image database and projecting any given image on these new bases, and measuring the matching between the given image and the pre-projected database in the new bases domain. The construction of the new bases comes as follows:

1) Implement an augmented matrix (A), each column in this matrix is one of the images on the given database. If we assume that the given database contains (k) images and each of them is mxn, then the dimension of the augmented matrix should be (mxn)xk.

2) Calculate the mean column of the augmented matrix and subtract each column from that mean.

3) Find the covariance matrix (S), where $S = AA^T$ (because the dimension of S will be huge then calculate another matrix which we call it Q where $Q = A^TA$, so the dimension of Q will be kxk)

4) Calculate the eigenvalues and eigenvectors of the matrix Q. and choose the Eigenvector corresponding to the nonzero Eigenvalues to construct an Eigenvector matrix Vq which should has a dimension of kxl where (l) is the number of chosen vectors.

5) Multiply A and Vq to get the new bases V (which is the actual Eigenvectors of the covariance matrix S) which has the dimension of (mxn)xl.

6) To find transform the existing database into the new Eigen space the inner product of each image with each vector in the V matrix. ($An=A^TV$ where An is the augmented matrix in the new space).

For the recognition, each input image should projected to the new Eigen space (as step 6) and find the best match between the projected image and each column in An (using Euclidian distance or correlation method). Figures 1,2,3 show samples of the databases and eigenfaces.

Figure 1: Sample of ORL AT&T database for one person

Figure 2: Sample Eigenfaces for ORL AT&T database

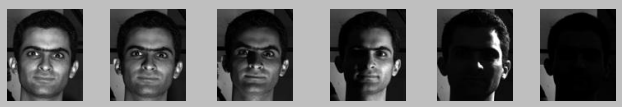
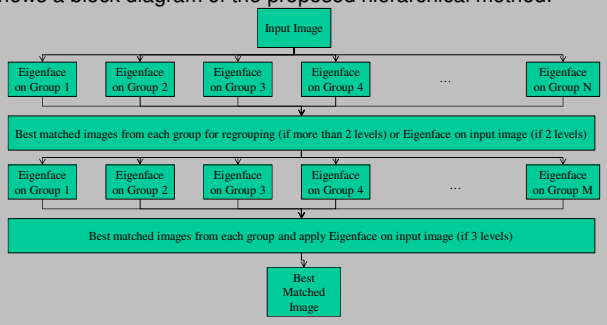


Figure 3: Sample of Extended B+ Yale database for one person

Hierarchical Eigenface technique

The recognition rate in standard Eigenface technique drops down as the number of images in the database increases. This lead to the idea of dividing the large image databases into groups such that each group has less than 100 images. After applying Eigenface algorithm on each of these groups, we pick a few top matched images from each group, then create new groups from these. Depending on the number of images, a number of hierarchical levels will be used. Eigenface algorithm is applied on each level group. Then in the final step, the top matched images from the final subgroups are collected, and Eigenface method is applied on this final group to select the best matched. Figure 4 shows a block diagram of the proposed hierarchical method.



Results

The proposed technique has been tested on two popular benchmark face databases: ORL AT&T and Extended Yale. The grouping algorithm used in all levels for both cases is k-means algorithm.

1) For the AT&T database, the number of images is 400. The images have been divided as 200 image for calculating the groups and Eigenfaces, and the other 200 for testing. Two level hierarchy has been implemented. For the first groups level, the group size is around 50. The recognition rate with the original Eigenface is 92.5%. It has been increased to 94.5% using our hierarchical method.

2) For the Extended B+ Yale database, the number of images in the database is 14,800 images. Again 50% of them are used for calculating the Eigenfaces and 50% for testing. Because of the huge amount of images, in this case, a three level hierarchy has been used. The training images have been divided into 140 groups with each of them having around 50 images. The recognition rate when original Eigenface algorithm is used is 55%, but when hierarchical method is used, the recognition rate increases in a range from 77% to 83.5% depending on the number of best images selected from each group in the first level, and the number of groups in the regrouping step in the second level. The recognition rate of 83.5% comes when selecting the 5 best matching images from each first level group, and then regrouping them again into 5 subgroups and reselecting 5 best matches from each subgroup and applying a final Eigenface step on them to find the best match.

Conclusion

From the results we can see that the recognition rate increased rapidly when hierarchical technique is used, especially for large databases (Extended B+ Yale). The system performance can be improved more by using different grouping criteria (dissimilarity or randomness), using balanced group size in each step, and using fast unsupervised learning technique for the grouping of the second and next levels.

References

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