PRML(STATS M231)

Project 1. PCA and FLD for Analyzing Human Faces

Dong Hyeon Won (104778048)

Part 1. ASM and AAM model for face recognition

1) Figure 1 is the mean face of the 150 train images. For 1), train images were not aligned. Figure 2 is the first 20 eigen-faces and figure 3 is the reconstructed faces of test faces. The reconstruction process used 20 eigen-faces. Figure 4 shows the how MSE between original faces and reconstructed faces changes when the number of eigen-faces used for reconstruction changes. We can observe that the error decreases when more eigen-faces were used. Since the explained variance for each eigen-face decreases as the eigen-value decreases, the slope of the error plot decreases.

Figure 1. Mean face for training faces

Figure 2. First 20 eigen-faces for training faces

Figure 3 Reconstructed test faces using 20 eigen-faces

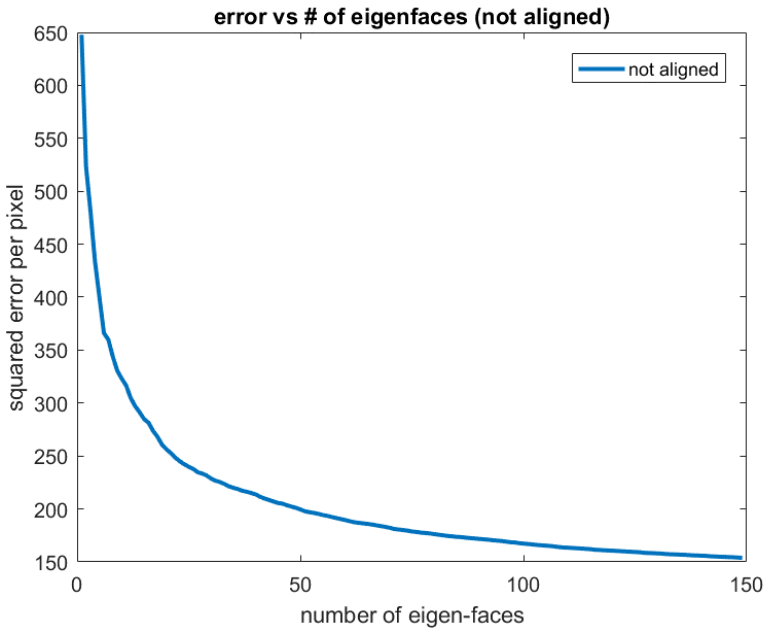

Figure 4. Reconstruction error (MSE) for not aligned eigen-faces

2) Red dots in figure 5 shows the mean landmark. Figure 6 describes the first 5 eigen-warpings. For each eigen-warpings in figure 6, left image is mean face warped to $mean\_landmark + 3 * \sigma_i * eigenwarp_i$ and right image is mean face warped to $mean\_landmark - 3 * \sigma_i * eigenwarp_i$. In this case, σ_i is the standard deviation of the data projected to ith principal component. This σ_i is equal to square root of corresponding eigen-value. Image in the center describes the direction of the each eigen-warping. Each eigen-warping has geometring meaning. For example, the thirst eigen-warping is related to listing head and the third eigen-warping is related to turning head. Figure 7 shows the error in terms of distance.

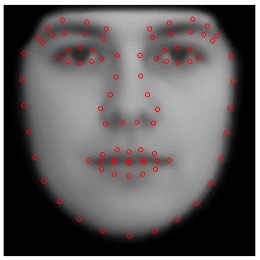

Figure 5. Mean landmark for training set

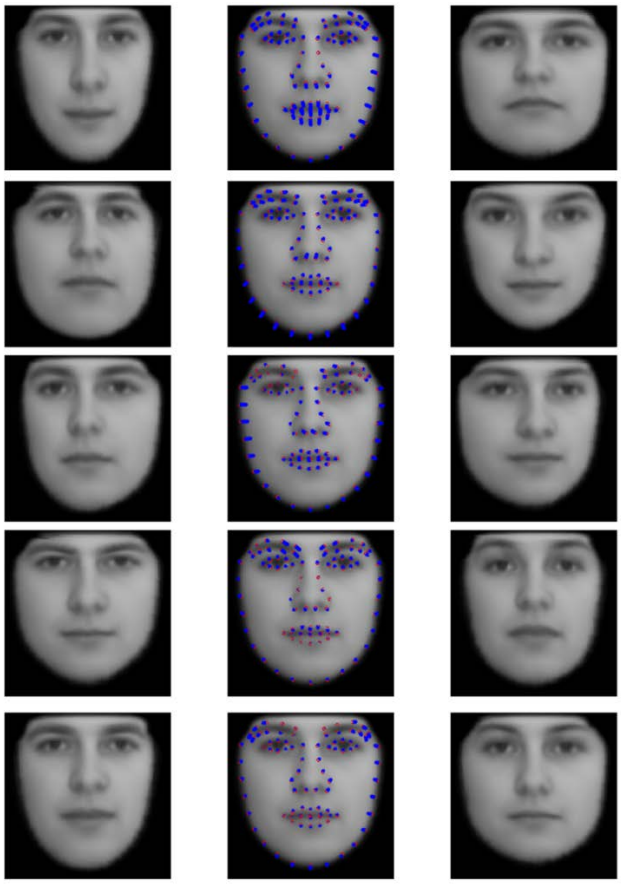

Figure 6. First 5 eigen-warpings

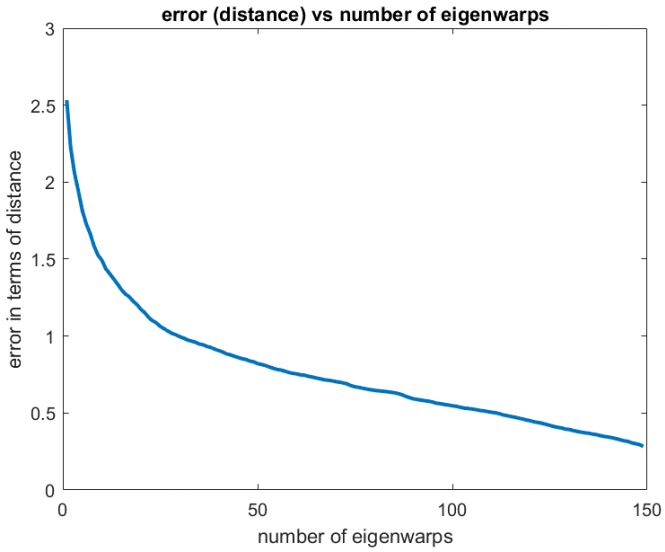

Figure 7. Reconstruction error vs number of eigen-warpings used

3) Figure 8 shows the reconstruction error of testing set using 10 eigen-warpings. The test faces were reconstructed as the following.

i) First, all the images were aligned with respect to the mean landmark. ii) The eigen-faces of the aligned train set were calculated after aligning. iii) Then, all the test images were warped to the mean landmark. iv) And then we project each image to top k eigen-faces. v) After that, we warp each image to reconstructed landmark using first 10 eigen-warpings.

When a small number of eigen-faces is used, the reconstruction error is smaller than the case in which eigen-warpings are not used.

The reconstructed faces using top 10 eigen-faces and top 10 landmarks are shown in figure 9.

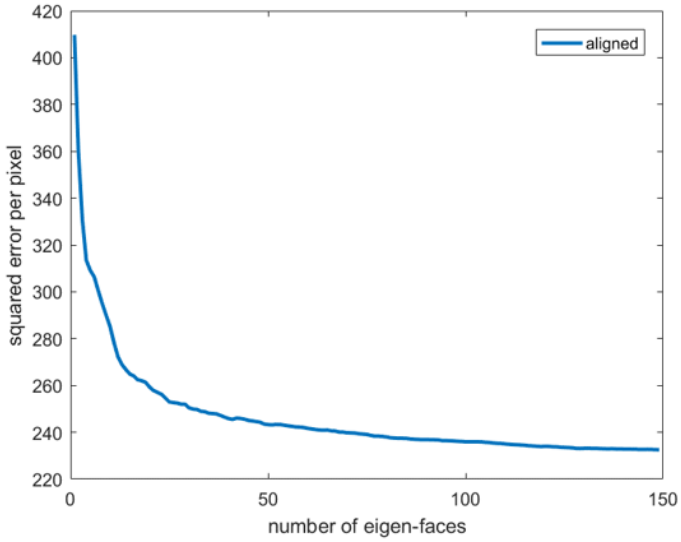

Figure 8. Reconstruction error (MSE) for aligned eigen-faces

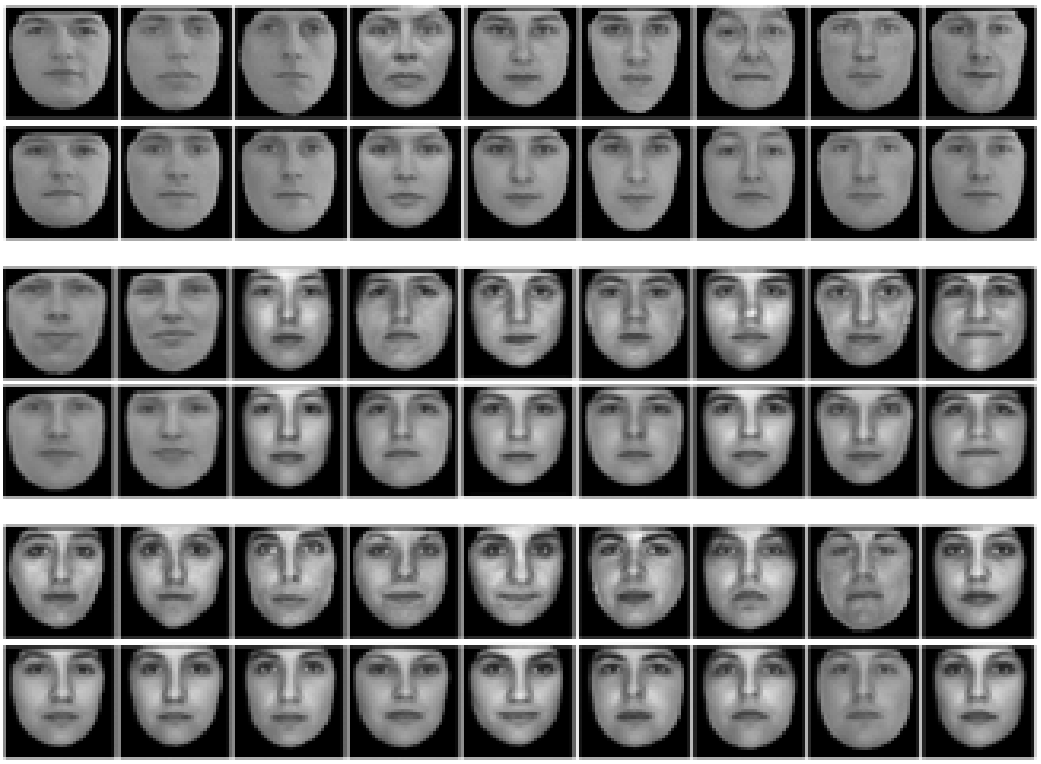

Figure 9. Reconstructed faces using 10 aligned eigen-faces and 10 eigen-warpings

4) The random faces generated with top 10 eigen-warpings and top 10 eigen-faces are shown in figure 10. The weight for each eigen-warping and eigen-faces were drawn from Gaussian distribution with mean of 0 and standard deviation of square root of corresponding eigenvalue.

Figure 10. Random face synthesized with top 10 eigen-warpings and top 10 eigen-faces

Part 2. Fisher faces for gender discrimination.

5) Figure 11 shows the fisher face that discriminates the gender. The fisher face was calculated with 88 male faces and 85 female faces. Figure 12 shows how fisher face discriminates the test set. The y value for each data point was given just for visualization purpose. As we can observe in figure 12, only two of the test data were misclassified.

Figure 11. Fisher face that discriminates male from female in the training set

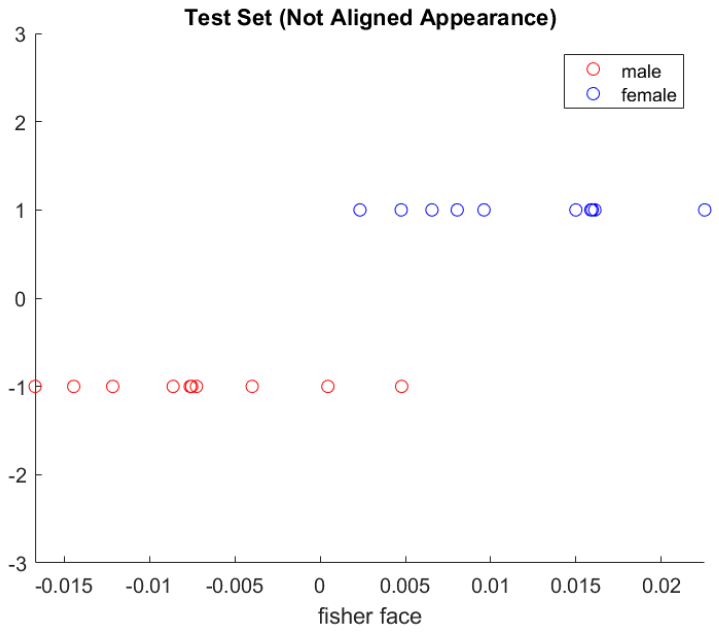

Figure 12. 20 testing faces projected to the fisher face

6) Figure 13 shows 20 aligned test faces projected to the aligned fisher face. Two of the test data were misclassified when using aligned fisher face. Figure 14 shows test landmarks projected to the fisher landmark. Three data points were misclassified when using fisher landmark. Figure 15 shows the test data points projected to the 2-D feature space. The x-axis is the aligned fisher face and the y-axis is the fisher landmark. Assuming a proper linear classifier, only one data point will be misclassified. The separability in this case is better than those of other cases in which only one feature is used.

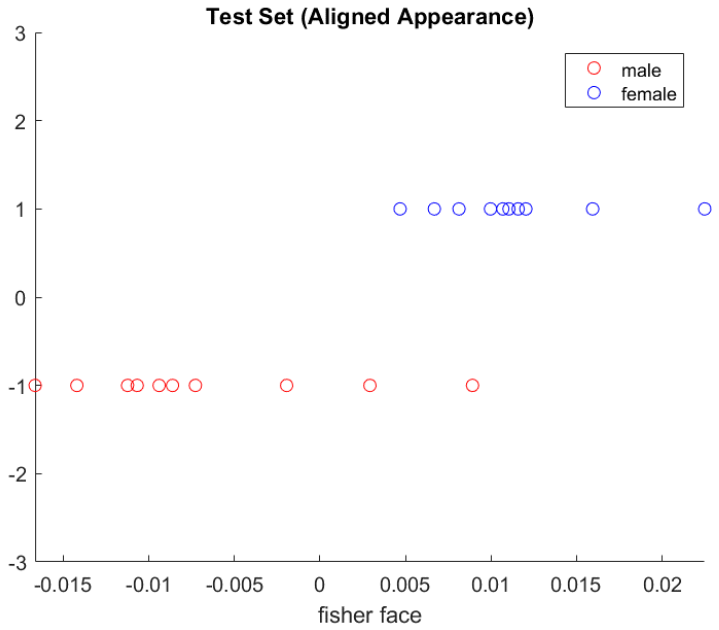

Figure 13. 20 aligned test faces projected to aligned fisher face

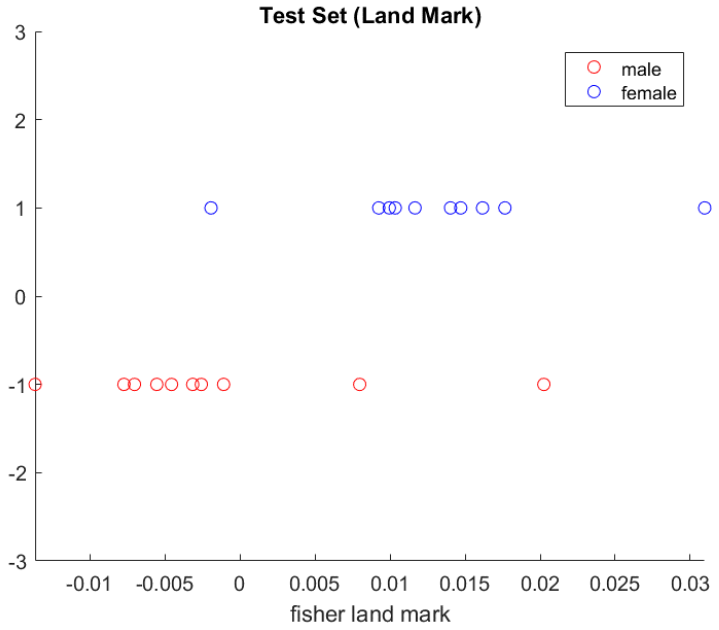

Figure 14. 20 test landmarks projected to fisher landmark

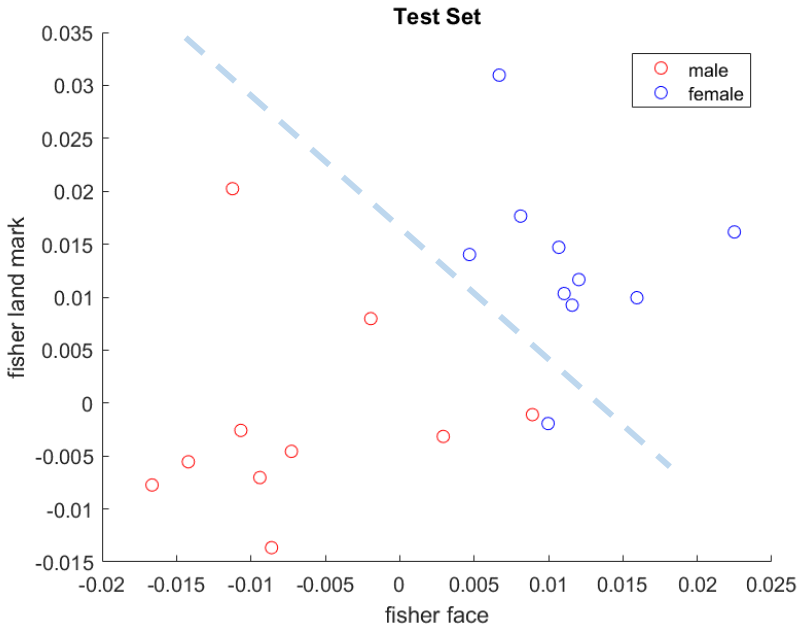

Figure 15. 20 test images projected to the 2--D feature space