Heritability of Facial Appearance

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Motivation

- The genetic factors influencing normal facial morphology are not well characterized
- Evidence for specific heritable components to facial morphology could be detectable in a set of related people with 2-dimension face images
- The first step is to consistently measure the proximity of facial features for each face image
- Then, data about relationships between people can be used to identify which of those features are most strongly inherited
- Here, we present our implementation of the first step: facial feature detection

Methods

Active Shape Model (ASM) [1] is a Statistical based Active Contour Model (Snake Model) for shape matching. The basic idea of the Snake Model is deforming the contour to fit the object.

The key different between ASM and the Snake model is that ASM is only able to deform contour by its statistical model (which consists of the training data).

The important step in the ASM algorithm is projecting the contour from the image space to the **Principle Component Analysis** (PCA) space, which is built from the training data set, in order to calculate the allowance adjustment. Then, the PCA space is mapped back to the image space for contour deformation.

Because of its statistical properties, the ASM is able to get better results for special shapes, if you have an adequate training data set.

Figure 1. The first picture is original front face image and the second one is applied on Active Shape Model.

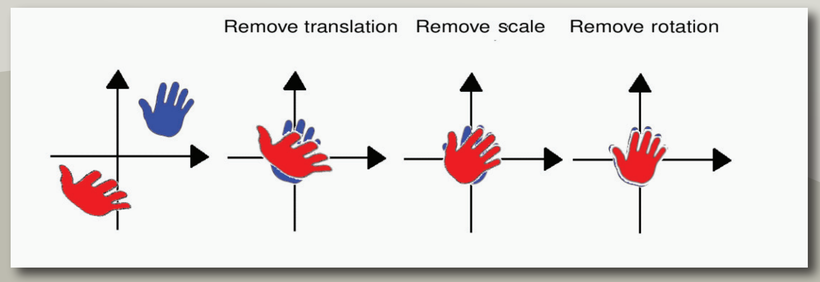

Figure 2. The illustration of General Procrustes Analysis.

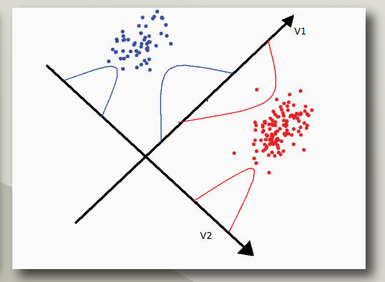

Figure 3. Example of Linear Discriminant Analysis.

After getting the landmarks from all images, we have to pre-process the data before the classification. The **General Procrustes Analysis** (GPA) [2] is to removes variability between images due to translation, scale and rotation. So we can classify the data without any additional varied factors.

Linear Discriminant Analysis (LDA) [3] is a classification algorithm used in machine learning to look for a linear combination of variables that fully explain the data.

LDA finds the singular value decomposition after defining the data matrix. The data is represented as orthogonal eigenvectors.

LDA has the useful property of increasing the distance between each cluster and increasing the density of each cluster, as shown in Figure 3.

In our case, LDA could not only project higher dimensional landmarks to lower dimensional space but also separates clusters well, resulting in fewer dimensions and better classification of distinct clusters.

Our Approach

We used the BioID dataset [4] which consists of 1521 gray level images with a resolution of 384x286 pixels. Each image shows the frontal view of a face of one out of 23 different test persons. The ASM was implement by C++. GPA and LDA were written in MATLAB.

In Figure 4, the LDA provides two distinct clusters. In Figure 5, LDA was applied to 7 different persons. The different colors represent different people and each point represents one image. The results demonstrate that combining ASM and LDA are possible solutions for the heritability problem.

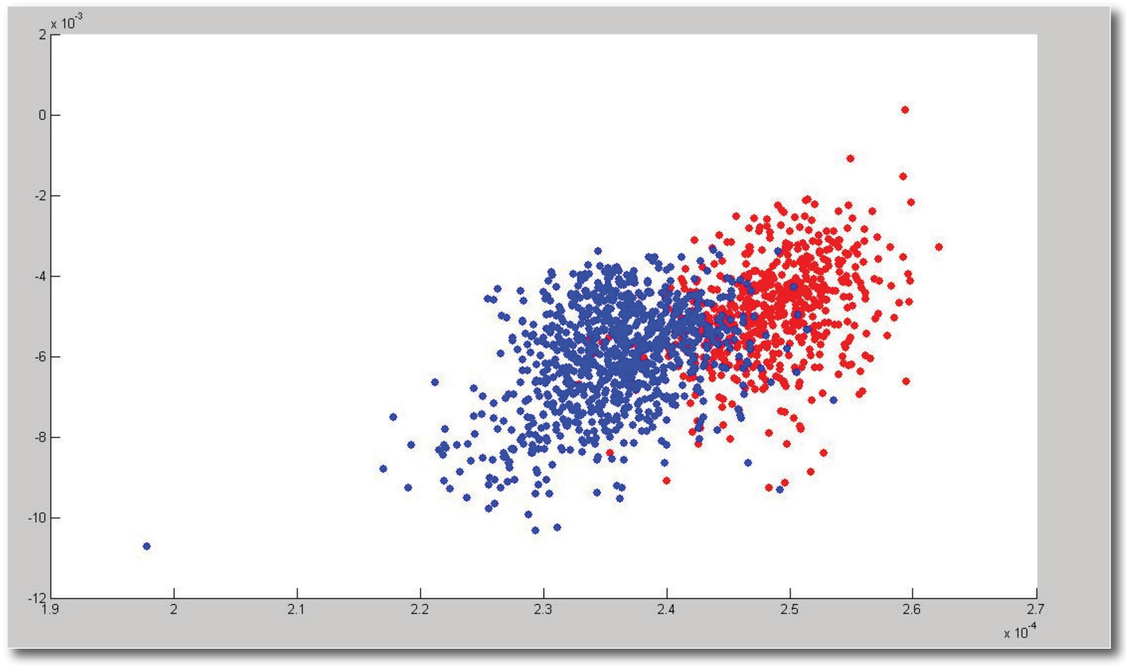

Figure 4. Result of LDA with two clusters, men (blue points) and women (red points)

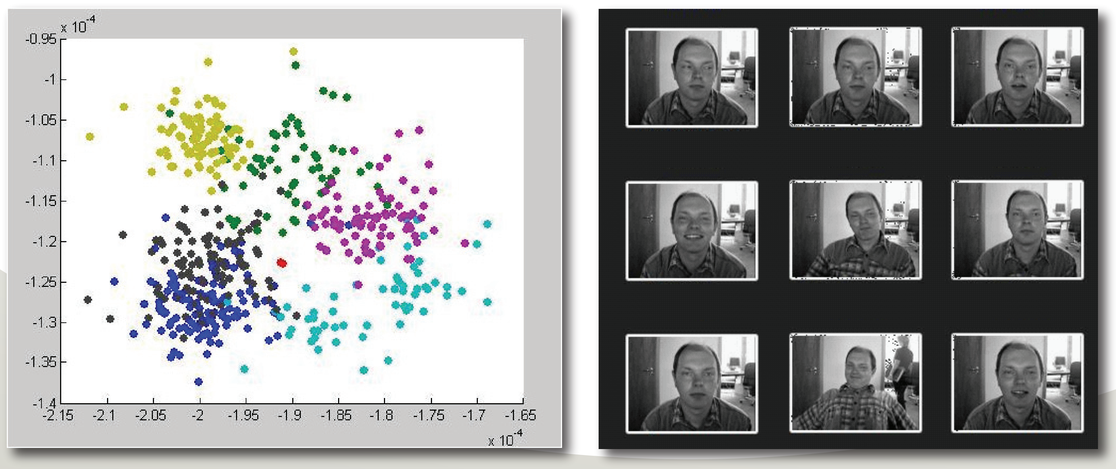

Figure 5. The result of LDA with 7 clusters. Each cluster has series of images for one person with different face locations or expressions.

Conclusion

The image processing methods outlined here can uniquely identify individuals by
- Distinguishing people using multiple images of each person
- Sex
- Family membership

Next Steps:
- We have applied the image processing method to a set of 1000+ photographic images belonging to 14 families
- We will use this unique image resource to estimate the heritability of facial morphologies
- Outcomes of this experiment could lead to applications in the field of DNA forensics

References

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