Computer Vision Laboratory - Tsukuba University

Monthly report - OCT. 2015

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November 4, 2015

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Introduction

In this first monthly report, I will show the work done during the month of October 2015.

Having no experience in the field of computer vision before, I had to learn many basic concepts of this field during the past month such as Principal Component Analysis, Linear Discriminant Analysis, the Bayesian Method and many more. Therefore, first, I will explain to you what I've learned, what research papers I've consulted. In order to understand the Subspace and the Mutual Subspace Method, this step was essential.

Then, I will show the results of the development of a face recognition system using Subspace Method and Mutual Subspace Method using Matlab software.

Finally, the last part will be about the difficulties I met during my research work and how I managed to find a solution for them.

Part 1 : Preparation

Introduction

As I said, I did not have any experience in the field of computer vision. Learning the basics of computer vision was a important step in order to understand more advanced methods of this field. The resources used in this preparation part were mostly research papers, web courses, but also thanks to advices given by members of the laboratory, I could understand certain concepts more easily.

Principal Component Analysis

The Principal Component Analysis (or PCA) method is used a lot in computer vision algorithms. Indeed, it is a linear transformation technique used to emphasize variation and bring out strong patterns in a dataset.

One of its strong points is Dimensionality Reduction. In the case of face recognition, the face images used often have a big dimensionality which is the number of pixels (or height*width). So even for small images like 100*100 pixel images, the dimensionality is huge (10000). That's why the PCA method is used. With this method, the data is reduced down into its basic components, omitting any unnecessary parts.

To understand this method well, I decided to implement the eigenfaces method for face recognition which was a good start as it is easy to understand and covers the entire PCA technique (with the eigenvalues and eigenvectors).

Learning how to use this method was very useful as it is used for many applications and many algorithms (Eigenfaces, Fisherfaces, Subspace Methods,...)

Parametric Eigenspaces

I also learned about a little bit more advanced version of the eigenspace method : the parametric Eigenspace. Whereas in the classic eigenspace method, such parameters such as illumination and pose are not considered, the parametric eigenspace do it. Like the eigenspace method, the parametric eigenspace consists of a learning phase and a recognition phase.

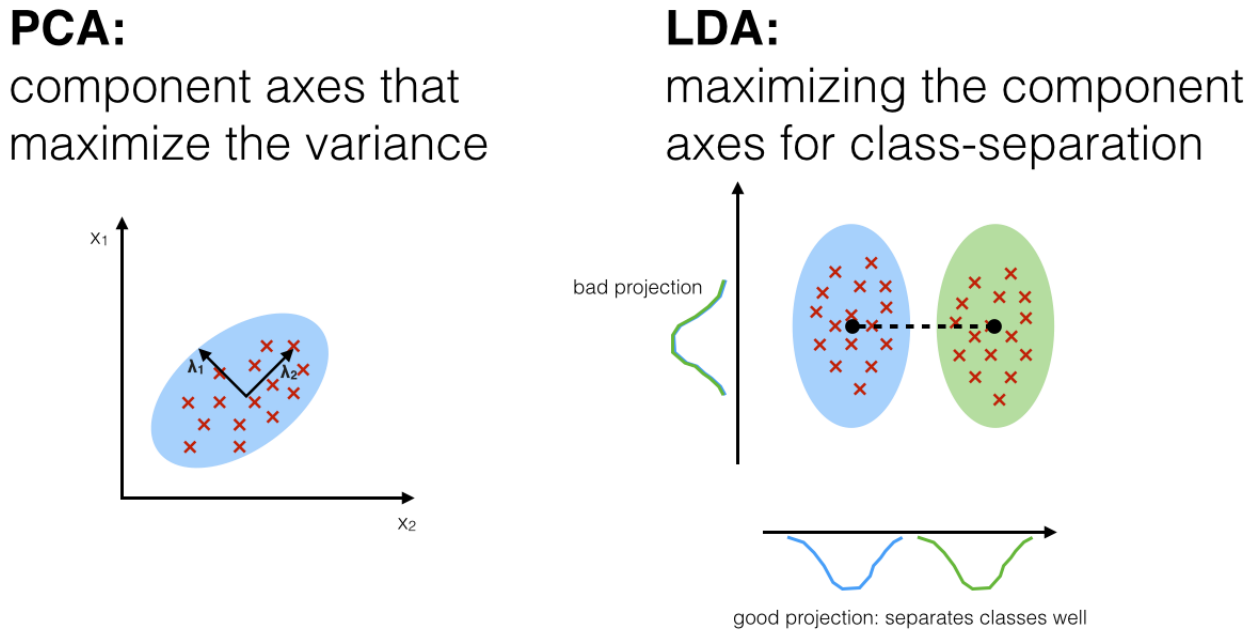
Basically, in the learning phase, we create the universal eigenspace using all the learning images and

after that comes the recognition phase where an input image is projected onto the universal eigenspace. The recognition problem then is to find the same object as the object of the input image in the eigenspace. After identifying it, we have to find the rotation parameter (or pose) and the illumination parameter of the object.

Learning this method has deepen my knowledge about eigenspace even though I don't think it was useful for the comprehension of subspace methods.

Linear Discriminant Analysis

Linear Discriminant is a linear transformation technique like the PCA that is commonly used for dimensionality reduction. Unlike PCA who ignores class labels and whose goal is to find the directions that maximize the variance in the dataset, LDA computes the directions ("linear discriminant") that will represent the axes that maximize the separation between multiple classes.



source : http://sebastianraschka.com/

As for PCA, I implemented the Fisherfaces algorithm that uses both PCA for dimensionality reduction and LDA for finding the axes that maximize the separation between the different classes.

Others

In addition to the previous methods, I also learned about other techniques and concepts used in face recognition and computer vision in general.

By recommendation of the members of the lab, I did some research about k Nearest Neighbors (kNN) algorithm.

I also tried to learn about Independent Component Analysis (ICA) and Bayesian Method that are mentioned in some research papers that I've read. I could not understand very deeply these methods because of the advanced mathematical formulas involved.

Now, I also know the difference between supervised and unsupervised learning algorithms. Unsupervised methods like PCA algorithm try to find a correlation in the dataset provided without help. Indeed, PCA does not consider classes and tries to find, in the case of face recognition, the image from the dataset that is the "closest" to the input image. Supervised methods, on the other hand, has some extra information that can help the machine make his decisions. In the case of face recognition, it would be the tag associated to each of the dataset image to classify each image beforehand.

Part 2 : Development

Introduction

After understanding the basic concepts mentioned in the previous part, understanding the Subspace Method and the Mutual Subspace Method was a lot easier. In this part, I show you the results of a face recognition system using Matlab software.

Subspace Method

Basically, the Subspace Method is composed of a learning step and then a recognition step. In the learning step, all the subspaces (each associated to one face) are generated. Then, in the recognition step, the similarities between a vector (corresponding to the input face image) and all the subspaces are computed. Then, the vector will be recognized as one of the subspace whose similarity is the lowest. However, the similarity has to be lower that a certain threshold. Otherwise, it would not be recognized as one of the known faces and as a face at all.

Mutual Subspace Method

The Mutual Subspace Method follows the same path for the learning step as for the Subspace Method. Nevertheless, in the recognition step, we compute the similarities between a subspace (corresponding to many images of the same face) and all the others subspaces from the learning step.

Face Recognition System

With Matlab, I developed a simple GUI using both subspace method and mutual subspace method.

To use it in subspace method mode, when choosing the directory for the learning step, your architecture must be like in figure 1. Then, for the input image, you can choose it from anywhere.

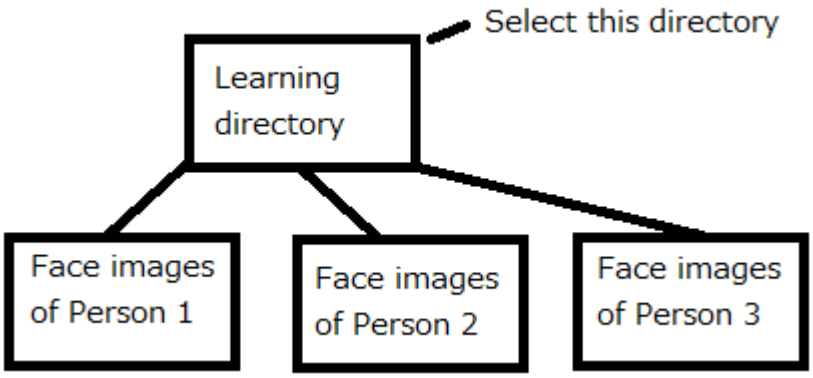


Figure 1 - Architecture of learning directory

In mutual subspace method mode, it is the same for the learning directory. But for the recognition directory, the architecture should be as in figure 2.

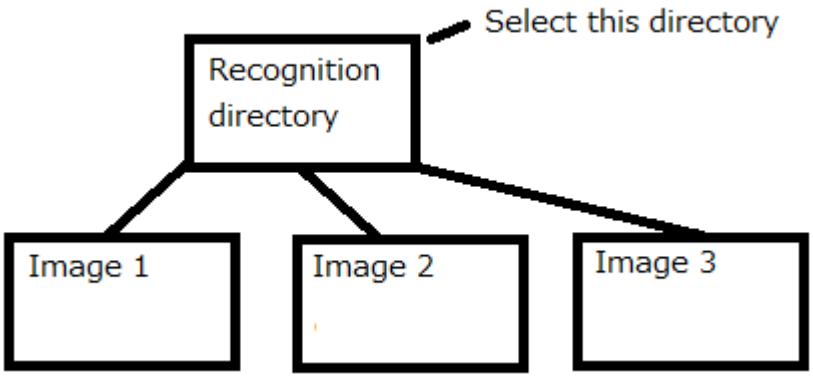


Figure 1 - Architecture of recognition directory

Below are some images of the GUI developed.

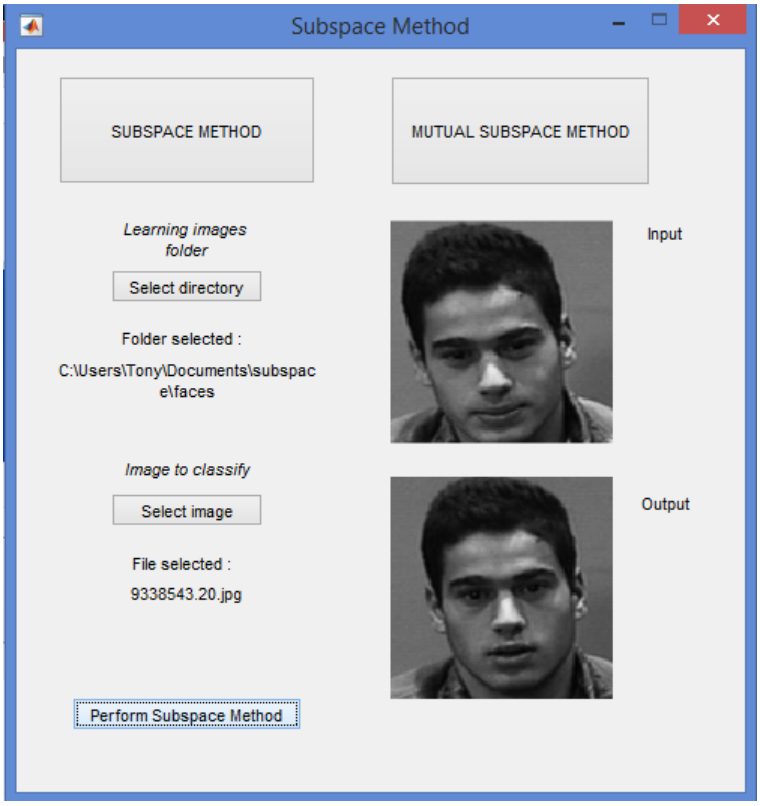


Figure 2 - GUI - Subspace Method

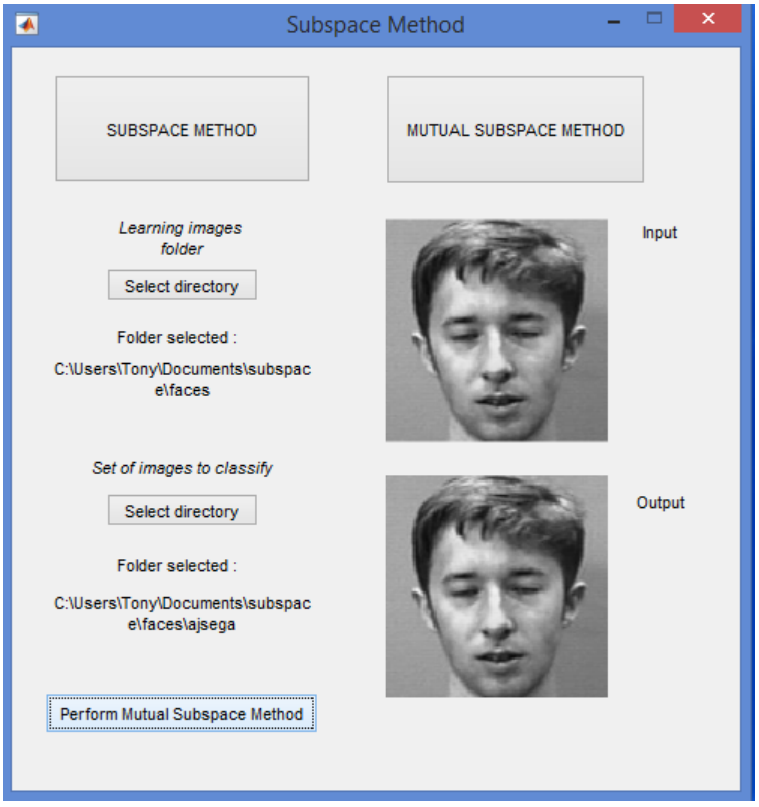


Figure 3 - GUI - Mutual Subspace Method

Part 3 : Difficulties

During my research work, I encountered many difficulties because of my lack of experience and knowledge.

First, knowing how and where to start was difficult. I tried to start by reading the book 'Subspace methods of Pattern Recognition' by E. Oja. But the more I read this book, the more I could not understand the concepts explained. Then, I tried to find research papers that are easier to read for me. By asking the members of the lab what should I study first, I was redirected to PCA method and indeed, it was very useful as I could understand many research papers in which PCA is mentionned.

Secondly, while reading research papers, I could sometimes understand the main idea but understanding the mathematical formulas was sometimes very difficult, most of the times even impossible for me at my current level. That's why I also study mathematics during my research work if I don't understand it.

Thirdly, as computer vision, especially face recognition is a very specialized field, resources on the internet are rare and difficult to find. Sometimes, determining the relevance of

Part 4 : Conclusion

During this month, I learned a lot about the different algorithms about pattern recognition. It helped me to understand how the whole process of recognizing and classifying a face works. It is often the same pattern : learning and recognizing. The differences between some algorithms are also not so big. That is why understanding Subspace Method and other algorithms was a lot easier after the comprehension of more basic methods. This month's work was concluded by a face recognition system using SM and MSM. For the next month, I will study how to detect and track a face from a camera and then do the recognition part with MSM method.

Part 5 : Bibliography

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Hitoshi Sakano, 'A Brief History of the Subspace Methods'

Gregory Shakhnarovich, Baback Moghaddam, 'Face Recognition in Subspaces' May 2004

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K. Ming Leung, 'Learning Vector Quantization'

Baback Moghaddam, Tony Jebara, Alex Pentland, 'Bayesian Face Recognition'

E. Oja, 'Subspace methods of Pattern Recognition'