Chapter 1

Introduction

1.1 Motivation

The rising public concern on security and the high demand for identity authentication in the digital world have triggered a real need for reliable, user-friendly, and widely acceptable control mechanisms for person authentication. Biometrics, which bases the person authentication on the intrinsic aspects of a human being, appears as a viable alternative to traditional approaches, such as PIN codes or passwords. Face recognition is a particularly compelling biometric because it is the common means which people use for identification in their visual interaction. Some advantages of face biometric are: A personal authentication system based on facial analysis is often effective without the participant's cooperation or knowledge, which makes it desirable in surveillance applications; acquisition of face images requires neither contact nor complex user processes; face images/videos are easily captured by low-cost acquisition devices.

In the past 30 years, especially in recent 10 years, face recognition has received ever-increasing research effort and a lot of achievements have been gained. However, the problem is far from being fully solved. In fact, face recognition is one of the most difficult pattern recognition problems. The main challenges of face recognition today are rotation in depth and broad lighting changes, together with personal appearance changes.

The goal of this work is to accomplish robust face recognition under near infrared illumination (NIR). The main benefits of the use of NIR are: the near infrared imagery is nearly invariant to changes in ambient illumination, which provides a direct way to address the illumination challenge of face recognition; common cameras with silicon sensors can be used to acquire near infrared images. Compared with thermal sensors, silicon sensors are inexpensive and able to capture images of high quality; the *bright pupil effect*, generated under the NIR illumination condition, can be employed to assist eye detection, which is a crucial step for automatic face recognition.

This dissertation covers the complete components of an automatic face recognition system. The main contributions of this work are:

1. construct a multi-modal database for person authentication under near infrared illumination. A low-cost hardware system has been built up and used to capture audio and video data under NIR. 74 individuals from Europe, Asia and Africa have been recorded. Different configurations have been considered in order to make the database practically useful for different research purposes.

2. accomplish robust eye detection under active near infrared illumination. The algorithm makes use of the *bright pupil effect* to localize the eye candidates. A novel thresholding approach based on Euler number is proposed, which makes a good trade-off between accuracy and complexity. To address the problem of eyeglasses and low pupil intensity, symmetry transform is employed as a remedy of the bright pupil effect. For eye candidate verification, it has been proved that appearance-based approach is more effective than circle matching.

3. propose a multi-block fusion scheme for face recognition, which does not limit itself to be used with a specific algorithm, but provides an easy way to combine global and local features to improve the performance of any algorithm in general;

4. propose effective approaches of feature extraction for face recognition. The properties of energy compaction and decorrelation of Discrete Cosine Transform (DCT) enable it to be a suitable feature extraction method for face recognition. The proposed blockwise DCT outperforms the holistic DCT, since the former integrates more local information. AdaBoost algorithm is exploited to select more powerful DCT coefficients. The novel variety of AdaBoost, the so-call *CorrAdaBoost* performs better than the original AdaBoost, while the cascade structure further improves the performance of CorrAdaBoost.

5. evaluate different classification approaches, including nearest neighbor classifier, nearest center classifier, Linear Discriminant Analysis (LDA), and Support Vector Machine (SVM). Among them, LDA shows the best performance.

6. implement video-based face recognition which is based on the proposed face representation and classification approaches. Exemplars are extracted from the training videos, which yields better results than the randomly selected training samples. Three various strategies of temporal integration, namely the max rule, the majority voting rule, and the probabilistic voting rule, are compared. True video-based face recognition based on a condensation algorithm that coherently uses both spatial and temporal information is realized.

1.2 Organization of the Work

The organization of this dissertation is illustrated in Figure 1.1.

The next chapter gives an introduction to biometric person authentication. Face recognition as the most acceptable technique of biometric person authentication is then elaborated. The state of the art of face recognition, the principal technologies, the commonly used public face databases and the evaluation protocols are depicted.

Chapter 3 presents a multi-modal database for person authentication under near infrared illumination. The hardware configuration and recording procedure are in details described. Part of the data are associated with manually marked labels in order to assist the quantitative analysis of algorithm performance.

Chapter 4 addresses the problem of eye detection under near infrared illumination. The bright pupil effect and symmetry transform are utilized to localize the eye candidates. A new effective thresholding algorithm is proposed. Two eye verification approaches are compared.

Chapter 5 covers the topic of feature extraction for face recognition. The principle of DCT and its properties are at first introduced. Diverse feature extraction schemes based on DCT are proposed, i. e. blockwise DCT, AdaBoosted DCT, CorrAdaBoosted DCT and Cascaded CorrAdaBoosted DCT.

Chapter 6 discusses various distance measures and classification methods. Their performance is compared and the most successful method is found.

Chapter 7 presents methods for face recognition from videos based on the proposed features and classification approaches. For training, exemplars are selected to represent each individual from training videos. For online recognition, two strategies are adopted, namely temporal integration and simultaneous tracking and recognition.

Chapter 8 concludes the important results of this dissertation and gives an outlook of the possible further work.

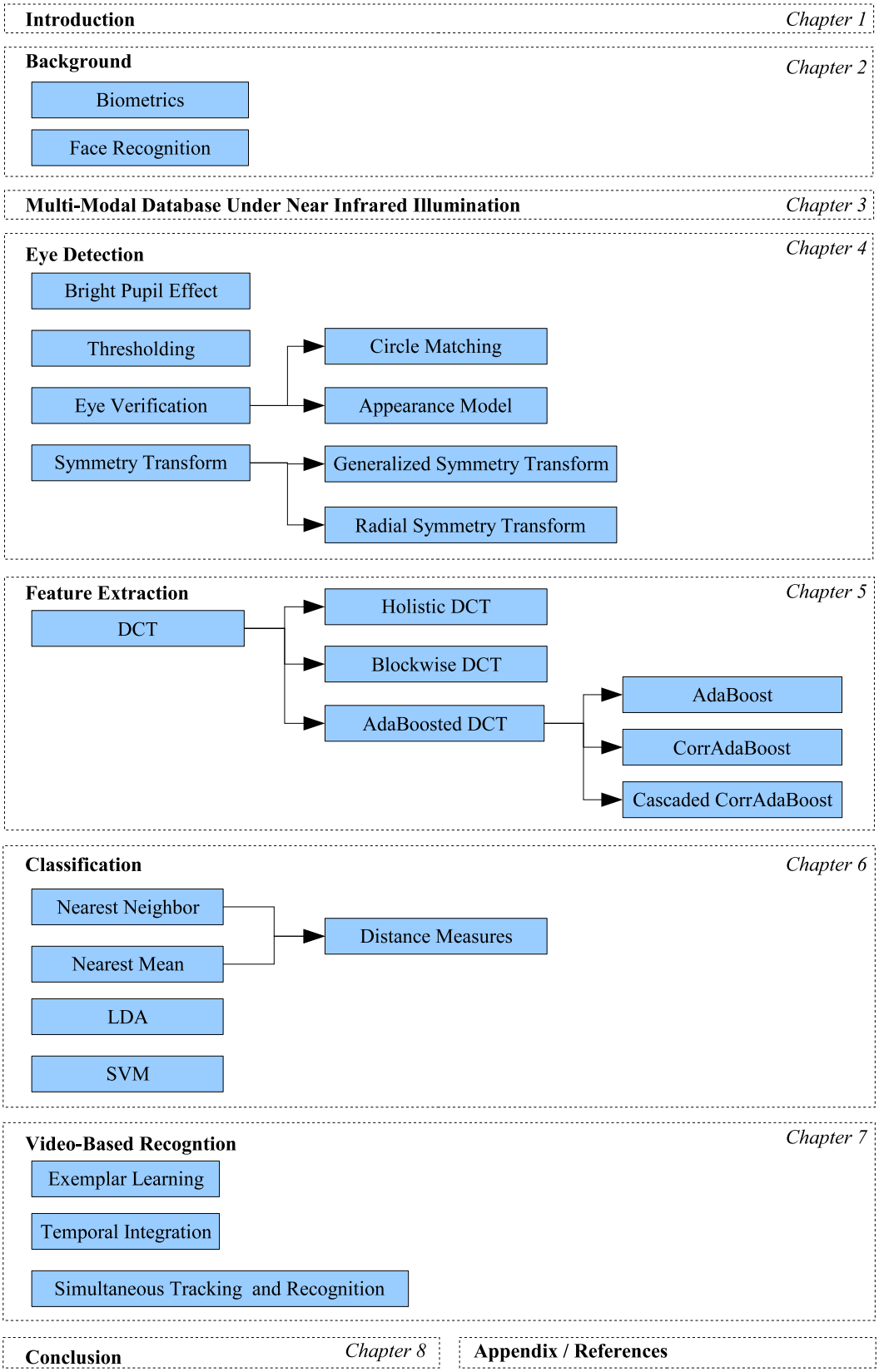

Figure 1.1: Layout of this dissertation