Chapter 1

Face Recognition System

1.1 INTRODUCTION

Ever since IBM introduced first personal computer on 1981, to the .com era in the early 2000s, to the online shopping trend in last 10 years, and the Internet of Things today, computers and information technologies are rapidly integrating into everyday human life. As the digital world and real world merge more and more together, how to accurately and effectively identify users and improve information security has become an important research topic.

Not only in the civil area, in particular, since the 9-11 terrorist attacks, governments all over the world have made urgent demands on this issue, prompting the development of emerging identification methods. Traditional identity recognition technology mainly rely on the individual's own memory (password, username, etc.) or foreign objects (ID card, key, etc.). However, whether by virtue of foreign objects or their own memory, there are serious security risks. It is not only difficult to regain the original identity material, but also the identity information is easily acquired by others if the identification items that prove their identity are stolen or forgotten. As a result, if the identity is impersonated by others, then there will be serious consequences.

Different from the traditional identity recognition technology, biometrics is the use of the inherent characteristics of the body for identification, such as fingerprints, irises, face and so on.

Compared with the traditional identity recognition technology, biological features have many advantages, as: 1. Reproducibility, biological characteristics are born with, cannot be changed, so it is impossible to copy other people's biological characteristics. 2. Availability, biological features as part of the human body, readily available, and will never be forgotten. 3. Easy to use. Many biological characteristics will not require individuals to corporate with the examine device. Based on the above advantages, biometrics has attracted the attention of major corporations and research institutes and has successfully replaced traditional recognition technologies in many fields. And with the rapid development of computer and artificial intelligence, biometrics technology is easy to cooperate with computers and networks to realize automation management, and is rapidly integrating into people's daily life.

When comparing the differences between different biometrics, we can see that the cost of facial recognition is low, the acceptance from user is easy, and the acquisition of information is easy. Facial recognition is the use of computer vision technology and related algorithms, from the pictures or videos to find faces, and then analysis of the identity. In addition, further analysis of the acquired face, may conduct some additional attributes of the individual, such as gender, age, emotion, and etc.

1.2 APPLICATION OF THIS RESEARCH

Face recognition can be traced back to the sixties and seventies of the last century, and after decades of twists and turns of development has matured. The traditional face detection method relies mainly on the structural features of the face and the color characteristics of the face.

Some traditional face recognition algorithms identify facial features by extracting landmarks, or features, from an image of the subject's face. For example, as shown in Figure 1.1, an algorithm may analyze the relative position, size, and/or shape of the eyes, nose, cheekbones, and jaw. These features are then used to search for other images with matching features. These kinds of algorithms can be complicated, require lots of compute power, hence could be slow in performance. And they can also be inaccurate when the faces show clear emotional expressions, since the size and position of the landmarks can be altered significantly in such circumstance.

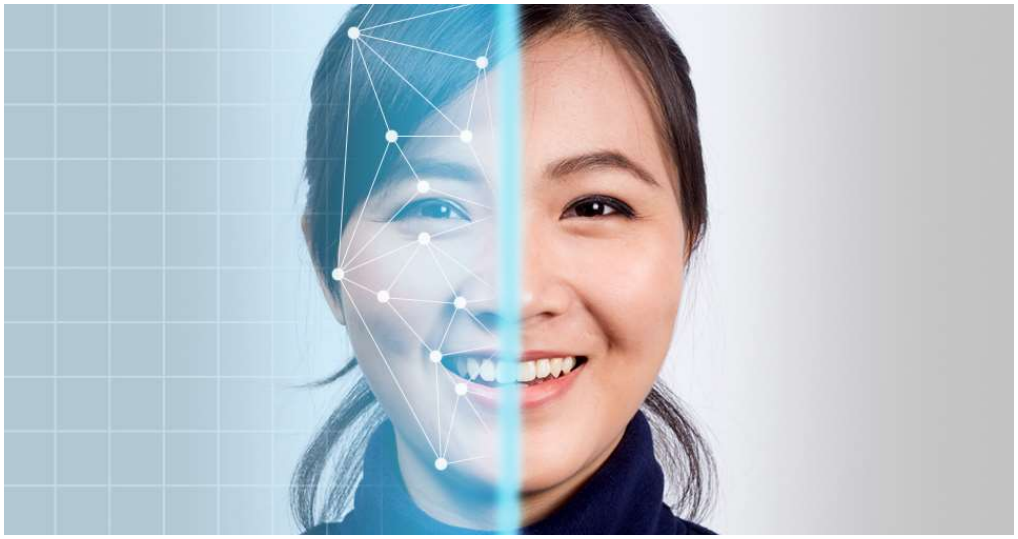

Figure 1.1 Abstract humane face into features [1]

1.3 ANALYSIS OF PROBLEM STATEMENT

A complete face recognition system includes face detection, face preprocessing and face recognition processes. Therefore, it is necessary to extract the face region from the face detection process and separate the face from the background pattern, which provides the basis for the subsequent extraction of the face difference features. The recent rise of the face based on the depth

of learning detection methods, compared to the traditional method not only shorten the time, and the accuracy is effectively improved. Face recognition of the separated faces is a process of feature extraction and contrast identification of the normalized face images in order to obtain the identity of human faces in the images.

In this paper, we will first summarize and analyze the present research results of face recognition technology, and studies a face recognition algorithm based on feature fusion. The algorithm flow consists of face image preprocessing, combination feature construction and combination feature training.

Chapter 2

Theoretical Background

2.1 ANALYSIS OF RELATED WORK

In Chapter 1, we introduced the facial recognition, discussed the use case and bright future of this technology. A tremendous amount of research and effort from many major company and universities and been dedicated to this field. In the first part of this chapter, we will review the most significant work in the facial recognition field.

2.1.1 FACE DETECTION AND FACE TRACKING

This article *Robust Real-time Object Detection* [2] is the most frequently cited article in a series of articles by Viola that makes face detection truly workable. We can learn about several face detection methods and algorithm from this publication. The article *Fast rotation invariant multi-view face detection based on real Adaboost* [3] for the first time real adaboost applied to object detection, and proposed a more mature and practical multi-face detection framework, the nest structure mentioned on the cascade structure improvements also have good results. The article *Tracking in Low Frame Rate Video: A Cascade Particle Filter with Discriminative Observers of Different Life Spans* [4] is a good combination of face detection model and tracking, offline model and online model, and obtained the CVPR 2007 Best Student Paper.

The above 3 papers discussed about the face detection and face tracking problems. According to the research result in these papers, we can make real time face detection systems. The main purpose is to find the position and size of each face in the image or video, but for tracking, it is also necessary to determine the correspondence between different faces in the frame.

2.1.2 FACE POSITIONING AND ALIGNMENT

Earlier localization of facial feature points focused on two or three key points, such as locating the center of the eyeball and the center of the mouth, but later introduced more points and added mutual restraint to improve the accuracy and stability of positioning Sex. The article *Active Shape Models-Their Training and Application* [5] is a model of dozens of facial feature points and texture and positional relationship constraints considered together for calculation. Although ASM has more articles to improve, it is worth mentioning that the AMM model, but also another important idea is to improve the original article based on the edge of the texture model. The regression-based approach presented in the paper *Boosted Regression Active Shape Models* [6] is better than the one based on the categorical apparent model. The article *Face Alignment by Explicit Shape Regression* [7] is another aspect of ASM improvement and an improvement on the shape model itself. Is based on the linear combination of training samples to constrain the shape, the effect of alignment is currently seen the best.

The purpose of the facial feature point positioning is to further determine facial feature points (eyes, mouth center points, eyes, mouth contour points, organ contour points, etc.) on the basis of the face area detected by the face detection / tracking, s position. These 3 articles show

the methods for face positioning and face alignment. The basic idea of locating the face feature points is to combine the texture features of the face locals and the position constraints of the organ feature points.

2.1.3 FACE FEATURE EXTRACTION

PCA-based eigenfaces [8] are one of the most classic algorithms for face recognition. Although today's PCA is more used in dimensionality reduction in real systems than classification, such a classic approach deserves our attention. The article *Local Gabor Binary Pattern Histogram Sequence (LGBPHS): A Novel Non-Statistical Model for Face Representation and Recognition* [9] is close to many mature commercial systems. In many practical systems, a framework for extracting authentication information is PCA and LDA. Using PDA to reduce matrix to avoid the matrix singularity problem of LDA solving, then using LDA to extract the features suitable for classification, To further identify the various original features extracted after the decision-level fusion. Although some of the LFW test protocols are not reasonable, there is indeed a face recognition library that is closest to the actual data. In this article, *Blessing Dimensionality: High-dimensional Feature and Its Efficient Compression for Face Verification* [10], the use of precise positioning point as a reference to face multi-scale, multi-regional representation of the idea is worth learning, can be combined with a variety of representation.

The above 3 papers discussed about facial feature positioning/alignment. Facial feature extraction is a face image into a string of fixed-length numerical process. This string of numbers is called the "Face Feature" and has the ability to characterize this face. Human face to mention

the characteristics of the process of input is "a face map" and "facial features key points coordinates", the output is the corresponding face of a numerical string (feature). Face to face feature algorithm will be based on facial features of the key point coordinates of the human face pre-determined mode, and then calculate the features. In recent years, the deep learning method basically ruled the face lift feature algorithm, In the articles mentioned above, they showed the progress of research in this area. These algorithms are fixed time length algorithm. Earlier face feature models are larger, slow, only used in the background service. However, some recent studies can optimize the model size and operation speed to be available to the mobile terminal under the premise of the basic guarantee algorithm effect.

2.2 THEORETICAL IDEA OF PROPOSED WORK

Face recognition is essentially pattern recognition, and the purpose is to abstract real things into numbers that computers can understand. If a picture is a 256 bit-color image, then each pixel of the image is a value between 0 and 255, so we can convert an image into a matrix. How to identify the patterns in this matrix? One way is to use a relatively small matrix to sweep from left to right and top to bottom in this large matrix. Within each small matrix block, we can count the number of occurrences of each color from 0 to 255. So we can express the characteristics of this block.

Through this scan, we get another matrix consisting of many small matrix block features. And this matrix is smaller than the original matrix. Then, for this smaller matrix, perform the above steps again to perform a feature "concentration". In another sense, it is abstracted. Finally, after

many abstractions, we will turn the original matrix into a 1 dimension by 1 dimension matrix, which is a number. Different pictures, such as a cat, or a dog, a bear, will eventually get abstracted to different numbers. Similarly, faces, expressions, ages, these principles are similar, but the initial sample size will be large, and ultimately the specific image is abstracted into numbers through the matrix. Then by calculating the difference between the matrixes, we can achieve the goal of comparing faces.