CHAPTER 2

LITERATURE SURVEY

2.1 GENERAL SURVEY OF FACE RECOGNITION

This chapter provides a detailed survey of face recognition research. There are two underlying motivations to present this survey: the first is to provide an up-to-date review of the existing literature, and the second is to offer some insights into the studies of machine recognition of faces. To provide a comprehensive survey, existing recognition techniques of face recognition are categorized and detailed descriptions of representative methods within each category are presented. In addition, relevant topics such as psychophysical studies, system evaluation, issues of illumination and pose variation are covered.

Automated face recognition was developed in 1960s. The first semi-automated system for face recognition required the administrator to locate features such as eyes, ears, nose, and mouth on the photographs before it calculating the distances and the ratios to a common reference point, which were then compared to the reference data. In 1970s, the problem with both of these early solutions was that the measurements and locations were manually computed. In 1990, Kirby and Sirovich applied Principal Component Analysis, a standard linear algebraic technique, to the face recognition problem. This was considered as a milestone. It is shown that less than one hundred values were required to accurately code a suitably aligned and normalized face image.
As a result of many studies, scientists come up with the decision that face recognition is not like other object recognition. Face recognition is one of the few biometric methods that possess the merits of both high accuracy and low intrusiveness. It has the accuracy of a physiological approach without being intrusive. For this reason, since the early seventies, face recognition has drawn the attention of researchers in fields from security, psychology and image processing.

Early face recognition algorithms used simple geometric models, but the recognition process has now matured into a science of sophisticated mathematical representations and matching processes. Since the early 1950s when digital computers were born and the world gained significant processing power, computer scientists have endeavored in bringing thought and the senses to the computer. During the 1980s, work on face recognition remained largely dormant. Plagued with the fears expressed in George Orwell’s 1984, most members of society are very concerned about the use of a computer system which is capable of recognizing them wherever they go. Since the 1990s, the research interest in face recognition has grown significantly as a result of the following facts:

1. The increase in emphasis on civilian/commercial research projects, the re-emergence of neural network classifiers with emphasis on real time computation and adaptation.

2. The availability of real time hardware.

3. The increasing need for surveillance related application due to terrorist and drug trafficking activities, etc.

In the year 1991, Turk and Pentland discovered that while using the Eigen faces techniques, the residual error could be used to detect faces in images, a discovery that enabled reliable real-time automated face recognition.
systems. This demonstration initiated much-needed analysis on how to use the technology to support national needs while being considerate of the public’s social and privacy concerns.

Critics of the technology complain that the London Borough of Newham scheme has, as of 2004, never recognized a single criminal, despite several criminals in the system's database living in the Borough and the system having been running for several years. "Not once, as far as the police know, has Newham's automatic facial recognition system spotted a live target." This information seems to conflict with claims that the system was credited with a 34% reduction in crime, which better explains why the system was then rolled out to Birmingham also.

In 2006, the performance of the latest face recognition algorithms was evaluated in the Face Recognition Grand Challenge (FRGC). High-resolution face images, 3-D face scans and iris images were used in the tests. The results indicated that the new algorithms are 10 times more accurate than the face recognition algorithms of 2002 and 100 times more accurate than those of 1995. Some of the algorithms were able to outperform human participants in recognizing faces and could identify even identical twins.

Tolba et al (2006) have reported an up-to-date review of major human face recognition research in “Face recognition: a literature review, methods and technologies of face recognition”. A literature review of the most recent face recognition techniques is presented. Description and limitations of face databases which are used to test the performance of these face recognition algorithms are given.

This face recognition problem is made difficult by the great variability in head rotation and tilt, lighting intensity, angle, facial expression, aging etc. Some other attempts at facial recognition by machine have allowed
for little or no variability in these quantities. Yet, the method of correlation or pattern matching of unprocessed data, which is often used by some researchers, is certain to fail in cases where the variability is great. In particular, the correlation is very low between two pictures of the same person with two different head rotations.

Modern face recognition has reached an identification rate greater than 90% with well-controlled pose and illumination conditions. The task of recognizing faces has attracted much attention both from Neuro-scientists and from computer vision scientists. While network security and access control are the most widely discussed applications, face recognition has also proven useful in other multimedia information processing areas.

2.2 SURVEY OF PCA AND LDA BASED FACE RECOGNITION

Numerous algorithms have been proposed for face recognition; Chellappa et al (1995), Zhang et al (1997) and Chan et al (1998) use face recognition techniques to browse video database to find out shots of particular people. Haibo Li et al (1993) code the face images with a compact parameterized facial model for low-bandwidth communication applications such as videophone and teleconferencing. Recently, as the technology has matured, commercial products have appeared on the market.


Vytautas Perlibakas (2004) has reported a method in “Face Recognition Using Principal Component Analysis and Wavelet Packet Decomposition” which allows using PCA based face recognition with a large number of training images and performing training much faster than using the traditional PCA based method.

Kyungnam Kim (1998) has proposed PCA to reduce the large dimensionality of the data space (observed variables) to the smaller intrinsic dimensionality of feature space (independent variables), which are needed to describe the data economically in “Face Recognition using Principle Component Analysis”. The original face is reconstructed with some error, since the dimensionality of the image space is much larger than that of face space.

Jun-Ying et al (2005) have combined the characteristics of PCA with LDA. This improved method is based on normalization of within-class average face image, which has the advantages of enlarging classification distance between different-class samples. Experiments were done on ORL (Olivetti Research Laboratory) face database. Results show that 98% of
correct recognition rate can be acquired and a better efficiency can be achieved by the improved PCA method.

El-Bakry (2007) has proposed a new PCA implementation for fast face detection based on the cross-correlation in the frequency domain between the input image and eigenvectors (weights) in “New Fast Principal Component Analysis for Face Detection”. This search is realized using cross-correlation in the frequency domain between the entire input image and eigenvectors. This increases detection speed over normal PCA algorithm implementation in the spatial domain.

Wangmeng Zuo et al (2006) have described in “Combination of two novel LDA-based methods for face recognition” the Combination of two LDA methods which performed LDA on distinctly different subspaces and this may be effective in further improving the recognition performance. Fisher face technology uses 2D-Gaussian filter to smooth classical Fisher faces.

Xiaoxun Zhang and Yunde Jia (2007) have explained the principal subspace, the optimal reduced dimension of the face sample in “A linear Discriminant analysis framework based on random subspace for face recognition Pattern Recognition” to construct a random subspace where all the discriminative information in the face space is distributed in the two principal subspaces of the within-class and between-class matrices.

Moshe Butman and Jacob Goldberger (2008) have introduced a face recognition algorithm in “Face Recognition Using Classification-Based Linear Projections” based on a linear subspace projection. The subspace is found via utilizing a variant of the neighborhood component analysis (NCA) algorithm which is a supervised dimensionality reduction method that has been recently introduced.
Changjun Zhou et al (2010) have introduced a features fusion method for face recognition based on Fisher’s Linear Discriminant (FLD) in “Features Fusion Based on FLD for Face Recognition”. The method extracts features by employing Two-Dimensional principal component analysis (2DPCA) and Gabor Wavelets, and then fuses their features which are extracted with FLD respectively.

Hui Kong Lei Wang et al (2005) have explained in their paper, “Framework of 2D Fisher Discriminant Analysis: Application to Face Recognition with Small Number of Training Samples” that 2D Fisher Discriminant Analysis (2D-FDA) is different from the 1D-LDA based approaches. 2D-FDA is based on 2D image matrices rather than column vectors so the image matrix does not need to be transformed into a long vector before feature extraction which contains unilateral and bilateral 2D-FDA.

Yanwei Pang et al (2004) have proposed “A Novel Gabor-LDA Based Face Recognition Method” in which face recognition method based on Gabor-wavelet with linear Discriminant analysis (LDA) is presented. These are used to determine salient local features, the positions of which are specified by the Discriminant pixels. Because the numbers of discriminant pixels are much less than those of the whole image, the amount of Gabor Wavelet coefficients is decreased.

Xiang et al (2004) have reported in “Face Recognition using recursive Fisher Linear Discriminant with Gabor wavelet coding” that the constraint on the total number of features available from Fisher Linear Discriminant (FLD) has seriously limited its application to a large class of problems. In order to overcome this disadvantage of FLD, a recursive procedure of calculating the Discriminant features is suggested. Work is currently under progress to study the various design issues of face recognition, and the objective is to achieve 99% accuracy rate for identity
recognition for all the widely used databases, and at least 80% accuracy for facial expression recognition for Yale database.

Juwei Lu et al (2003) have shown in “Regularization Studies on LDA for Face Recognition”, that the applicability of Linear Discriminant Analysis (LDA) to high-dimensional pattern classification tasks such as face recognition (FR) often suffers from the so-called small sample size (SSS) problem arising from the small number of available training samples compared to the dimensionality of the sample space. The effectiveness of the proposed method has been demonstrated through experimentation using the FERET database.

Chengjun Liu and Harry Wechsler (2002) have reported in “Gabor Feature Based Classification (GFC) using the Enhanced Fisher Linear Discriminant Model for Face Recognition” that the feasibility of the proposed GFC method has been successfully tested on face recognition using a data set from the FERET database, which is a standard 16 tested for face recognition technologies.

2.3 SURVEY OF NEURO AND FUZZY BASED FACE RECOGNITION

Rowley et al (1998) have provided a neural network-based upright frontal face detection system in “Neural Network-Based Face Detection”. To collect negative examples, a bootstrap algorithm is used, which adds false detections into the training set, as training progresses.

Jianming Lu et al (2007) have presented a new method of face recognition on fuzzy clustering and parallel neural networks, based on the neuron-fuzzy system. The face patterns are divided into several small-scale
parallel neural networks based on fuzzy clustering, and they are combined to obtain the recognition result.

Yu et al (2001) has discussed Multiple Fisher Classifiers Combination for Face Recognition based on Grouping Ada Boost Gabor Features. The key issue in using Gabor features is how to efficiently reduce its high dimensionality. Gabor-based representation is too high dimensional even after being selected by some feature selection methods. In order to increase the total dimension of FDA subspace, the AdaBoosted Gabor features are regrouped into some smaller feature subsets.

Hongzhou Zhang et al (2007) have implemented face recognition by reconstructing frontal view features using linear transformation in “Face Recognition Using Feature Transformation” under different poses. Fei Zuo and Peter (2008) have introduced a fast face detector using an efficient architecture in “Cascaded face detection using neural network ensembles” based on a hierarchical cascade of neural network ensembles with which enhanced detection accuracy and efficiency are achieved.

Dmitry Bryliuk and Valery Starovoitov (2002) in “Access Control by Face Recognition Using Neural Networks” have considered a Multilayer Perceptrons Neural Network (NN) for access control based on face image recognition. The robustness of NN classifiers with respect to the False Acceptance and False Rejection errors is studied. A new thresholding approach for rejection of unauthorized persons is proposed.

Jun Zhang et al (1997) have compared three recently proposed algorithms for face recognition: eigenfaces, auto association and classification neural nets, and elastic matching in “Face Recognition: Eigenfaces, Elastic Matching, and Neural Nets”.

Smach et al (2005) have implemented a classifier based on neural networks MLP (Multi-layer Perception) for face detection in “Design of a Neural Networks Classifier for Face Detection”. The MLP is used to classify face and non-face patterns. Then a Hardware implementation is achieved using VHDL based Methodology. The system was implemented in VHDL and synthesized using Leonardo synthesis tool. The model’s robustness has been obtained with a back propagation learning algorithms.

According to Kakarwal et al (2009), it is important to select the invariant facial features especially faces with various pose and expression changes in Information Theory and Neural Network based Approach for Face Recognition. This work presents some novel feature extraction techniques such as Entropy and Mutual Information. For classification, feed forward neural network is used which will be better than traditional methods for accurately recognizing the faces.

Gaile (1992) have explored the use of morphological operators for feature extraction in range images and curvature maps of the human face in “Application of Morphology to Feature Extraction for Face Recognition”. This paper has described general procedures for locating features defined by the configuration of extrema in principal curvature. A novel connection technique based on the concept of constrained skeleton was also introduced in this paper. This technique being based on a proximity rule defined by a structuring element, it could be used successfully for a variety of applications.
Sushmita Mitra and Sankar (2005) have explained that Fuzzy sets are well-suited to modeling different forms of uncertainties and ambiguities, often encountered in real life in “Fuzzy sets in pattern recognition and machine intelligence”. Fuzzy set theory is the oldest and most widely reported component of present day soft computing, which deals with the design of flexible information processing systems.

Vonesch et al (2005) have illustrated the flexibility of the proposed design method in “Generalized bi-orthogonal Daubechies wavelets”. Most importantly, it is possible to incorporate a priori knowledge on the characteristics of the signals to be analyzed into the approximation spaces, via the exponential parameters.

Alaa Eleyar and Hasan Demiral (2007) have proposed PCA and LDA based Neural Network for Human Face Recognition. Lekshmi and Sasikumar (2009) have analysed both the Global and Local Information for Facial Expression Recognition.

Fatma et al (2008) have discussed in “Comparison between Haar and Daubechies Wavelet Transformations on FPGA Technology” that the Daubechies wavelet is more complicated than the Haar wavelet. Daubechies wavelets are continuous; thus, they are more computationally expensive to use than the Haar wavelet. This wavelet type has balanced frequency responses but non-linear phase responses. Daubechies wavelets use overlapping windows, so the high frequency coefficient spectrum reflects all high frequency changes.

Manjunathi and Ma (1996) have suggested “Texture Features for Browsing and Retrieval of Image Data” that a novel adaptive filter selection strategy in Gabor Wavelets to reduce the image processing computations while maintaining a reasonable level of retrieval performance.
Hossein Sahoolizadeh et al (2008), has proposed a new hybrid method of Gabor wavelet faces using extended NFS classifier in “Face Detection using Gabor Wavelets and Neural Networks”. Down sampled Gabor wavelets transform of face images as features for face recognition in subspace approach is superior to pixel value approach.

Yousra Ben Jemaa and Sana Khanfir (2009) have discussed in “Automatic local Gabor features extraction for face recognition” that Face is represented with its own Gabor coefficients expressed at the fiducial points (points of eyes, mouth and nose). The first is composed of geometrical distances automatically extracted between the fiducial points. The second is composed of the responses of Gabor wavelets applied in the fiducial points and the third is composed of the combined information between the previous vectors.

From the literature review, it is found that in 1970s, typical pattern classification techniques were used to measure attributes between features in faces or face profiles. During the eighties, work on face recognition remained largely dormant. Since the early nineties, research interest in Face Recognition Technology has grown very significantly.

Over the last ten years, increased activity has been seen in tackling problems such as segmentation and location of a face in a given image and extraction of features such as eyes, mouth, etc. Also, numerous advancements have been made in the design of statistical and neural network classifiers for face recognition. There are many methods that have been proposed in the literature for the facial recognition task. However, all of them have still disadvantages such as not complete reflection about face structure and face texture. Therefore, a combination of different algorithms which can integrate the complementary information should lead to improve the efficiency of the entire system.
Actually, development of face recognition over the past years allows an organization into three types of recognition algorithms, namely frontal, profile, and view-tolerant recognition, depending on the kind of images and the recognition algorithms. While frontal recognition certainly is the classical approach, view-tolerant algorithms usually perform recognition in a more sophisticated fashion by taking into consideration some of the underlying physics, geometry and statistics. Profile schemes as stand-alone systems have a rather marginal significance for identification. However, they are very practical either for fast coarse pre-searches of large face database to reduce the computational load for a subsequent sophisticated algorithm, or as part of a hybrid recognition scheme.

The following observations were made after surveying the research literature:

1. Some features of face or image subspace may be simultaneously invariant to all the variations that a face image may exhibit.

2. Given more number of training images almost any technique will do better and the number of test images will decide the performance. These two actors are the major reasons why face recognition is not widely used in real – world application.

The commercial applications range from static matching of photographs on credit cards, ATM cards, passports, driver’s licenses and photo ID to real-time matching with still images or video image sequences for access control.

Principal Component Analysis and Fisher Discriminant Analysis for face recognition problems are elaborately discussed in the next chapter.