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Face Recognition using Face Alignment and PCA Techniques: A Literature Survey

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Abstract: *The face is our key of attention in social communication, playing a main role in transmission identity and sentiment. Hence, Face recognition has become an important issue in many applications such as security systems, credit card verification and criminal identification. In human face profiles, the shape and size of eyes, nose, mouth and their relationship have been commonly used as a feature. With correctly extracted features, we can easily recognize a humane face. However, only little work has been done in literature on low-resolution face recognition and partial face recognition. Numerous alignment methods and techniques have been developed for face recognition. In this literature survey, we are presenting a study in Face Alignment techniques for Face Recognition and presenting a brief introduction about face recognition process. The main keys issue of this literature survey is to be classified based face alignment techniques on their drawbacks in finding a solution to some of the above-mentioned problems. Moreover, this paper presents a concise description about the Face Alignment and PCA techniques and the instructions for future research.*

Keywords: *Face Recognition, Face Alignment Techniques, Active Appearances Model (AAM), Active Shape Model (ASM), Principle Component analysis (PCA).*

I. Introduction

Face Recognition has been an important and challenging research area for scientists and engineers even before the advent of modern electronic computers [1]. Face recognition is an assignment that humans perform characteristically and naturally in daily life. Identical almost each and every task connected with the human brain perceptive abilities, cognition, consciousness etc., and face recognition is also a curiosity [2] [3]. Human faces are normally recognized based on comparison of basic features (i.e. eyes, nose and mouth) set in some general pattern. The proficiency to discriminate one face from another depends on the fine-grained analysis of a faces feature and complete information on face. As a component and holistic based face recognition techniques have complementary strengths and weaknesses, a well-designed face recognition system uses both component and holistic information in the recognition process. Face recognition plays an important role in our day-to-day lives for identification and authentication purpose. An important issue in face recognition research is whether faces are recognized based on their individual features or more holistically, based on their overall shape [4] [5]. In Face recognition, they recognized an individual by matching the input face image with face images of all users in the training data set and find the best match. It is used as an attempt to identify a person or verify a person's claimed identity. It is an unsolved problem under the conditions of pose and illumination variations [6] [7]. Face recognition has received this great deal of attention because of its applications in various domains like Security, identity verification, video surveillance, Criminal justice systems and forensic, multimedia environments [8].

1.1 Face recognition is used for two primary tasks.

- Verification (one-to-one matching): When presented with a Face image of an unknown individual along with a claim of identity, ascertaining whether the individual is who he/she claims to be.
- Identification (one-to-many matching): Given an image of an unknown individual, determining that person’s identity by comparing (possibly after encoding) that image with a database of (possibly encoded) images of known individuals [12].

A complete face recognition system generally consists of three stages. The first stage involves detecting and localizing the face in arbitrary images. The second stage requires extraction of pertinent feature from the localized image obtained in the first stage. Finally, the third stage involves classification of facial images based on derived feature vector obtained in the previous stage. In order to design a high accuracy recognition system, the choice of feature extraction method is very crucial [9]. The essential problems in the face recognition area remain unsolved, especially under the practical unconstrained imaging conditions. Clearly, the challenges lie in not only the academic level but also the application system designing level [10].

1.2 Methods for Face Recognition

Majority of face recognition methods apply mostly to frontal faces. Three main subjects are concerned for face recognition:

i) Face image preprocessing
ii) Feature extraction
iii) Classification:

- **Face image preprocessing:** Due to the limited dynamic ranges of current imaging and display devices, images captured in real world scenes with high dynamic ranges usually exhibit poor visibility of either over exposed or shadows and low contrast, to cope with this problem, various image processing techniques have been developed. Some of those techniques are spatially independent methods, like gamma adjustment, logarithmic compression, histogram equalization (HE), and levels/curve methods.
- **Feature extraction:** Feature extraction, a special form of dimensionality reduction, is the process of computing a compact numerical representation that can be used to characterize a pattern. The design of descriptive feature for a specific application is the main challenge in building pattern recognition systems.
- **Classification:** Basic-level categorization is the most common entry point for classification but the basic level of classification is not enough information to identify faces. This occurs if information outside the long-term memory matches the information to be retrieved; the retrieval process helps in facial recognition.

Face recognition is an effective research field and the earlier work mainly dealt with different complex conditions, like pose, illumination, and expression variations [11]. However, low-resolution face recognition and partial face recognition (occlusion) remain as major challenges in face recognition and these two problems affect the performance of face recognition in surveillance, access control and authentication applications [14].

Major research works carried out in Face recognition techniques, applied to face images are discussed in this section. In Face recognition techniques, PCA and much Face Alignment technique are discussed below:

1.3 Principal Component Analysis (PCA): PCA is one of the most successful techniques that have been used in image recognition and compression. PCA is a statistical method under the broad title of factor analysis. PCA is a classical and the benchmark algorithm for face recognition [15].The jobs, which PCA can do, are prediction, redundancy removal, feature extraction, data compression, etc. Because PCA is a classical technique, which can do something in the linear domain, applications having linear models are suitable, such as signal processing, image processing, system and control theory, communications, etc. The main idea of using PCA for face recognition is to express the large 1-D vector of pixels constructed from 2-D facial image into the compact principal components of the feature space. This can be called Eigen space projection. Eigen space is calculated by identifying the eigenvectors of the covariance matrix derived from a set of facial images (vectors) [13].The advantage of PCA comes from its generalization ability. It reduces the feature space dimension by considering the variance of the input data. The method determines which projections are preferable for representing the structure of the input data. Those projections are selected in such a way that the maximum amount of information (i.e. Maximum variance) is obtained in the smallest number of dimensions of feature space [16].

1.3 Face Alignment techniques

Accurate face alignment is important for extracting good facial features, which in turn is important for achieving success in applications such as face recognition, expression analysis and face animation [17]. Extensive research has been conducted on image feature alignment over the past 20 years. One of the bottlenecks in a practical face recognition system is the face alignment problem, i.e., labeling some (even each) pixel with the high-level semantics related to its facial physiologic configuration. For instance, the pixel located at the eye corner should be labelled with “eye corner”. Face alignment is also vital to gaze tracking, pose estimation, expression classification etc. [18].

The objective is to align the images jointly in order to avoid a biased template selection. However, joint alignment of real world objects like human faces remains a difficult problem due to the following challenges: a) they often undergo both rigid transformations and non-rigid deformations. b) Different faces of different people have dramatically different appearances under a variety of illumination conditions, which poses asleep challenge for their alignment [19].The goal of the alignment process is to make the angularity at each flex plane of the coupling Sufficiently small with the machine in operation. This statement assumes a spool piece coupling. If the coupling has a single flex-plane, then the offset between the centerlines of the shafts at the flex-plane must be made sufficiently small, as well as the angularity [20].

II. Review of Recent Researches on Face recognition

Several research methodologies in Face recognition system mainly considered the face alignments techniques like AAM and ASM. Some other face recognition techniques accomplish the face recognition process by using PCA. Several systems were developed for face recognition by exploiting aforementioned techniques. In literature, we present a brief discussion about the face recognition techniques using AAM, ASM and PCA methods.

2.1 Literature Survey on Face recognition by using Active Appearance Model

Fitting an AAM for face recognition of minimizing the error between the input image and the closest model instance; solving a nonlinear optimization problem, which is presented in [21]. Although linear in both shape and appearance, overall, AAMs are non-linear parametric models in terms of the pixel intensities. The propose model can be an efficient fitting algorithm for AAMs based on the inverse compositional image alignment algorithm. They have shown that the effects of appearance variation during fitting could be recomputed ("projected out") using this algorithm and how it can be extended to include a global shape-normalizing warp, typically a 2D similarity transformation.

One of the problems of AAMs is that it was difficult to model a sufficiently wide range of human facial appearances, the pattern of intensities across a face image patch, which is proposed in [22]. The main contribution is to find a suitable facial appearance modeling method for AAMs by a comparative study. In the experiments, PCA, NMF, LNMF, and ns-NMF were used to produce the appearance model of the AAMs and the root mean square (RMS) errors of the detected feature points were analyzed using the AR and BERC face databases. The proposed results showed that 1: If the appearance variations of testing face images were relatively non-sparser than those of training face images, the non-sparse methods (PCA, NMF) based AAMs outperformed, the sparse methods (nsNMF, LNMF) based AAMs. 2: If the appearance variations of testing face images are relatively sparser than those of training face images, the sparse methods (nsNMF) based AAMs outperformed the non-sparse methods (PCA, NMF) based AAMs.

A model of the joint variation of shape and appearance of portions of an image sequence. The model is conditionally linear, and can be thought of as an extension of active appearance models to exploit the temporal correlation of adjacent image frames, which is proposed in [23]. Inference of the model parameters could be performed efficiently using established numerical optimization techniques borrowed from finite-element analysis and system identification techniques.

It was proposed two-stage scheme technique for online non-rigid shape recovery toward AR applications using Active Appearance Models (AAMs) in [24]. This poses a challenging task to recover non-rigid shape and global pose in real-time AR applications. First, they construct 3D shape models from AAMs offline, which do not involve processing of the 3D scan data. Based on the computed 3D shape models, they proposed an efficient online algorithm to estimate both 3D pose and non-rigid shape parameters via local bundle adjustment for building up point correspondences. The recovered 3D pose parameters can be used for AR registrations. Furthermore, the facial feature could be tracked simultaneously, which is critical for many face related applications. They evaluated algorithms on several video sequences. Promising experimental results demonstrate proposed scheme was effective and significant for real-time AR applications.

The model de-couples the shape and the texture variety of objects, which is followed by an efficient gradient-based model fitting method. Duet the flexible and simple framework, AAM has been widely applied in the fields of computer vision, which is presented in [25]. However, difficulties were met when it was applied to various practical issues, which lead to many prominent improvements to the model. In this proposed method, it was motivated us to review the recent advances of AAM. Therefore, these algorithms were summarized from three aspects, i.e., efficiency, discrimination, and robustness. Additionally, some applications and implementations of AAM are also enumerated.

In Active Appearance Models (AAMs) are generative parametric models that have been successfully used in the past to model faces proposed in [26]. However, suggests that the performance of an AAM built to model the variation in appearance of single person across pose, illumination, and expression (a Person Specific AAM) is substantially better than the performance of an AAM built to model the variation in appearance of many faces, including unseen subjects not in the training set (a Generic AAM). In the proposed method, they present an empirical evaluation that shows that Person Specific AAMs were, as expected, both easier to build and more robust to fit than Generic AAMs. Moreover, they shows that: i) building a generic shape model is far easier than building a generic appearance model, and the shape component is the main cause of the reduced fitting robustness of Generic AAMs. For both refinements, they demonstrate dramatically improved fitting performance. Finally, they evaluated the effect of these improvements on a combined model construction and fitting task.

A variety of applications are possible, including dynamic head pose and gaze estimation for real-time user interfaces, lip-reading, and expression recognition. To construct an AAM, a number of training images of faces with mesh of canonical feature points are needed proposed in [27]. All feature points have to be visible in all training images. However, in many scenarios parts of the face may be occluded. Perhaps the most common cause of occlusion was 3D posed variation, which can cause self-occlusion of the face. Furthermore, tracking using standard AAM fitting algorithms often fails in the presence of even small occlusions. In the proposed algorithms to construct AAMs from occluded training images and to track faces efficiently in containing occlusion. It was evaluated in proposed algorithms both quantitatively and qualitatively and show successful real-time face tracking on a number of image sequences containing varying degrees and types of occasions.

A statistical Active Appearance Model (AAM) is developed to track and detect eye blinking in [28]. The model has been designed to be robust to variations of head pose or gaze. In particular, they analyzed and determine the model parameters, which encode the variations caused by blinking. This global model was further extended using a series of sub-models to enable independent modeling and tracking of the two eye regions. Several methods to enable measurement and detection of eye-blink are proposed and evaluated. The results of various tests on different image databases are presented to validate each model.

An implementation of the Active Appearance Model that is able to track a face on a mobile device in real-time, which is presented in [29]. They achieved this performance by discarding an explicit texture model, using fixed-point arithmetic for much of the computation, applying a sequence of models with increasing complexity, and exploiting a sparse basis projection via Hear-like features. They have shown that the Hear-like feature basis achieves similar performance to more traditional approaches while being more suitable for a mobile device. Finally, they discuss the mobile applications of the system such as face verification, teleconferencing and human-computer interaction.

In face recognition industry, face recognition technique is introducing facial expression variations using a model-based approach in [31]. The approach follows in 1) Modeling an active appearance model(AAM) for the face image, 2) Using optical flow based temporal features for facial expression variations estimation, 3) and finally applying binary decision trees as a classifier for facial identification. The novelty lies not only in generation of appearance models which is obtained by fitting active shape model (ASM) to the face image using objective but also using feature vector which is the combination of shape, texture and temporal parameters that is robust against facial expression variations. The result has been performed on Cohn-Kanade facial expression database using 61 subjects of the database with image sequences consisting of more than 4000 images. This achieved a successful recognition rate up to 91.17% using decision tree as classifier in the presence of six different facial expressions.

The performance of a novel active appearance model (AAM) based fully automatic system for pose robust face recognition that allows faster fitting to main view and the generation of virtual views, which is presented in [32]. The system follows a multi-resolution scheme, where the first level is used to initialize a generic AAM, pose angle is automatically estimated using eigenvector analysis, and then a pose-dependent AAM model is selected. Recognition results over CMU PIE database show similar values compared with the performance achieved with manually landmarked faces. Compared with classical view-based approach, this multi-resolution scheme performs similarly but is sensibly faster.

Face verification and face identification are two main applications for face recognition. Based on the face representation which they use appearance-based methods in [33]. Unfortunately, the existing current model-based schemes are used for the applications of face identification and are not suitable for face verification. A novel scheme, which is custom-built for face verification applications, is therefore proposed in this paper. An active appearance model, a 2D morph able face model, is chosen and applied to realize the proposed scheme.

The Active Appearance Model (AAM) has been shown powerful for modeling images of deformable objects [34]. AAM uses Principal Component Analysis (PCA) based linear subspaces to model the 2D shapes and textures of the images of a target object class. Such a representation allows AAM to represent a certain image very small number of parameters. A suitable constrained initialization is presented in matching process to make converge better and quicker. They demonstrate the application of the scheme to the task of face recognition and experimental results show it is effective.

Statistical region-based registration methods such as the active appearance model (AAM) are used for establishing dense correspondences in images in [35]. At low resolution, images correspondences can be recovered reliably in real-time. However, as resolution increases this becomes infeasible due to excessive storage and computational requirements. They demonstrate the use of two types of bases, namely wavelets and wedge lets. The former extends the previous work of Wolstenholme and Taylor where Haar wavelet coefficient subsets were applied. The latter introduces the wedgelet regression tree based on triangulated domains. Dimensionality reduction by subsampling in the CDF 9–7 wavelet and wedgelet representations yield better results than 'standard' sub sampling in the pixel domain. They show that the bi-orthogonal CDF 9–7 wavelet yields better results than the Haar wavelet. Wedgelet representation is superior to wavelet representations at high dimensionality-reduction rates. At low rejection rates, an edge enhanced wavelet representation provides better segmentation accuracy than the full standard AAM model.

2.2 Literature Survey on Face recognition by using Active Shape Model

The original active shape model (ASM) has already been applied to the areas such as image segmentation, feature point localization, and contour extraction in [36]. However, the original ASM suffers from the loss of accuracy and low speed in real time applications. In this scheme, the improvement of the performance of the original ASM concerns the following three aspects. Firstly, the profile of the original ASM is extended from 1D to 2D. Secondly, each profile related to different features are constructed separately. Thirdly, the length of the profile varies with different levels. The simulations are carried out using the SJTU dataset, which contains 2273 face images. The experimental results demonstrate that the proposed scheme exhibits better performance than the original ASM.

In particular, the problem of accurate segmentation of the prominent features of the face in front view images is addressed in [37]. They proposed a method that generalizes linear Active Shape Models (ASMs), which have already been used for this task. The technique was built upon the development of a nonlinear intensity model, incorporating a reduced set of differential invariant features as local image descriptors. These features are invariant to rigid transformations, and a subset of them is chosen by Sequential Feature Selection for each landmark and resolution level. Methodology has demonstrated a significant improvement in segmentation precision as compared to the linear ASM and Optimal Features ASM in the tests performed on AR, XM2VTS, and EQUINOX databases.

They make some simple extensions to the Active Shape Model, and use it to locate features in frontal views of upright faces in [38]. They have shown on independent test data that with the extensions the Active Shape Model compares favorably with methods that are more sophisticated. The extensions are i) fitting more landmarks than are actually needed, ii) selectively using two- instead of one-dimensional landmark templates iii) adding noise to the training set iv) relaxing the shape model where advantageous (v) trimming covariance matrices by setting most entries to zero, and stacking two Active Shape Models in the series.

The face image differences caused by rotations are often larger than the inter-person differences used in distinguishing identities, which is presented in [39].Face recognition across pose, on the other hand, has great potentials in many applications dealing with uncooperative subjects, in which the full power of face recognition being a passive biometric technique could be implemented and utilized. Extensive efforts have been put into the research toward pose-invariant face recognition in recent years and many prominent approaches have been proposed. Their strategies, advantages/disadvantages and performances are elaborated. By generalizing different tactics in handling pose variations and evaluating their performances, several promising directions for future research have been suggested.

This work is done in [40] for a simple and very efficient solution to align facial parts in unseen images. Their solution relies on a Point Distribution Model (PDM) face model and a set of discriminant local detectors, one for each facial landmark. In this Discriminative Bayesian Active Shape Model (DBASM) formulation, the MAP global alignment is inferred by a Linear Dynamical System (LDS) that considers this information. The Bayesian paradigm provides an effective fitting strategy, since it, combine in the same framework both the shape prior and multiple sets of patch alignment classifiers to further improve the accuracy. Extensive evaluations were performed on several data sets including the challenging Labeled Faces in the Wild (LFW). The proposed Bayesian optimization strategy improves on the state-of-the-art while using the same local detectors. They have also shown that MOSSE filters further improve on these results.

Biometric features in face recognition systems are one of the most reliable and least intrusive alternatives for personal identity authentication presented in [41]. Active shape model (ASM) is an adaptive shape matching technique that has been used often for locating facial features in face images. However, the performance of ASM can degrade substantially in the presence of noise or near the face frame contours. In this correspondence, they propose a new ASM landmark selection scheme to improve the ASM performance in face recognition applications. The proposed scheme selects robust landmark points where relevant facial features are found and assigns higher weights to their corresponding features in the face classification stage. The experimental results are promising and indicate that our approach tends to enhance the performance of ASM, leading to improvements in the final face classification results.

In this work [42], have shown that the ear is a promising candidate for biometric identification. However, the preprocessing of ear images has had manual steps and algorithms do not necessarily handle problems caused by hair and earrings. They presented a complete system for ear biometrics, including automated segmentation of the ear in a profile view image and 3D shape matching for recognition. They evaluated this system with the largest experimental study to date in ear biometrics, achieving a rank-one recognition rate of 97.8 percent for an identical scenario and an equal error rate of 1.2 percent for a verification scenario on a database of 415 subjects and 1,386 total probes.

Human-machine interfaces (HMI) have been created for disabled and elderly people to control intelligent wheelchairs (IW) using facial and head gestures in [43]. To operate a wheelchair in this new visual-based control mode, user identification should be conducted beforehand. Rather than traditional user identification that requires the user to input his/her username and password by typing, the state-of-the-art biometric-based user identification provides a more convenient way for the disabled users. This paper first elaborates an active shape model in details; as an extension, an adaptive learning module is designed to append or update the user's face record in the constructed face database.

A gait recognition system using infrared (IR) images. Since an IR camera is not affected by the intensity of illumination, it is able to provide constant recognition performance regardless of the amount of illumination, which is presented in [44]. Model-based object tracking algorithms enable robust tracking with partial occlusions or dynamic illumination. However, this algorithm often fails in tracking objects if strong edge exists near the object. Replacement of the input image by an IR image guarantees robust object region extraction because background edges do not affect the IR image. In conclusion, the proposed gait recognition algorithm improves accuracy in object extraction by using IR images and the improvements to finally increase the recognition rate of gaits.

Active Shape Model (ASM) is one of the unique methods for image alignment, which is described in [45]. To improve its matching accuracy, they have proposed an ASM searching method was combined with a simplified Elastic Bunch Graph Matching (EBGM) algorithm. Considering that EBGM is too time-consuming, landmarks are grouped into contour points and inner points, and inner points are further separated into several groups according to the distribution around salient features. For contour points, the original local derivative profile matching is exploited. While for every group of inner points, two pre-defined control points are searched by EBGM, and then used to adjust other points in the same group by using an affine transformation. Experimental results have shown that the proposed method greatly improves the alignment accuracy of ASM with only a little increase of time requirement since EBGM is only applied to a few control points.

An improved Active Shape Model (ASM) for facial features extraction developed in [46] suffers from factors such as, poor model initialization, modeling the intensity of the local structure of the facial features, and alignment of the shape model to a new instant of the objecting a given image using simple Euclidian transformation. The core of enhancement relies on three improvements) initializing the ASM model using the center of the mouth and eyes, which are located using color information) incorporating RGB color information to represent the local structure of the feature points, and c) applying 2Daffine transformation in aligning the facial features that are perturbed by head pose variations, which effectively aligns the matched facial features to the shape model and compensates for the effect of the head pose variations. Experiments on a face database of 70 subjects show that our approach outperforms the standard ASM and is successful in extracting facial features.

A texture-constrained active shape model (TC-ASM) to localize a face in an image in [47]. TC-ASM effectively incorporates not only the shape prior and local appearance around each landmark, but also the global texture constraint over the shape. Therefore, it performs stable to initialize, accurate in shape localization and robust to illumination variation, with low computational cost. Extensive experiments were provided to demonstrate their algorithm.

The active shape model (ASM) has been used successfully to extract the facial features of a face image under frontal view in [48]. They have proposed a modified shape model, which can adapt to face images under different orientations. An energy function is defined that links up these two representations of a human face. In order to represent a face image under different poses, three models are employed to represent the important facial features: the left-viewed, right-viewed, and frontal-viewed models. The genetic algorithm (GA) is applied to search for the best representation of face images. Experimental results demonstrate that their proposed method can achieve a better performance in representing face images under different perspective variations and facial expressions than the conventionalism can.

Robust gait recognition algorithms for human identification from a sequence of segmented noisy silhouettes in a low-resolution video [49]. The proposed recognition algorithm enables automatic human recognition from model-based gait cycle extraction based on the prediction-based hierarchical active shape model (ASM). The proposed algorithm overcomes drawbacks of existing works by extracting a set of relative model parameters instead of directly analyzing the gait pattern. The performance of the proposed algorithm has been evaluated by using the Humanoid Gait Challenge data set, which is the largest gait benchmarking data set with 122 objects with different realistic parameters including viewpoint, shoe, surface, carrying condition and time.

An improved active shape model is proposed in this paper. The proposed algorithm includes the following four aspects [50]. Firstly, this paper adopts a semi-automatic facial feature point-marking tool. Secondly, this paper proposes to extract 2D gradient feature on the highest level and the higher level of multi-resolution pyramid images, and use Gabor wavelet transformations to extract the lower level's 2D texture feature. Thirdly, this paper adopts a new method of decomposition of the multi - resolution pyramid. Pyramid images are got by wavelet transform. Finally, this paper uses an improved searching scheme of multi-resolution pyramid. The length of the 2D profile-searching rectangle is changed according to different pyramid levels. Experimental results demonstrate that the proposed algorithm exhibits better performance than the original ASM.

2.3 Literature Survey on Face recognition by using Principal Component Analysis

A face recognition technique is developed based on depth and color information. The main objective of the paper is to evaluate three different approaches for face recognition and quantify the contribution of depth in [51]. The proposed face recognition technique is based on the implementation of the principal component analysis algorithm and the extraction of depth and color Eigen faces. Experimental results have shown significant gains attained by the addition of depth information.

A face recognition algorithm based on modular PCA approach is presented in [52]. The proposed algorithm when compared tithe conventional PCA algorithm has an improved recognition rate for face images with large variations in lighting direction and facial expression. In the proposed technique, the face images are divided into smaller sub-images and the PCA approach were applied to each of these sub-images. Since some of the local facial features of an individual do not vary even when the pose, lighting direction and facial expression vary, they expect that the proposed method to be able to cope with these variations. The accuracy of the conventional PCA method and modular PCA method are evaluated under the conditions of varying expression, illumination and pose using standard face databases.

Face recognition is a rapidly growing research area due to increasing demands for security in commercial and law enforcement applications, which is presented in [53]. This method provides an up-to-date review of research efforts in face recognition techniques based on two-dimensional (2D) images in the visual and infrared (IR) spectra. However, the performance of visual face recognition may degrade under poor illumination conditions or for subjects of various skin colors. IR imagery represents a viable alternative to visible imaging in the search for a robust and practical identification system. While visual face recognition systems perform relatively reliably under controlled illumination conditions, thermal I face recognition systems are advantageous when there is no control over illumination or for detecting disguised faces. Face recognition using 3D images is another active area of face recognition, which provides robust face recognition with changes in pose.

Face recognition has received substantial attention from researchers in biometrics, pattern recognition field and computer vision communities in [54]. Principal Component Analysis (PCA) is a technique among the most common feature extraction techniques used in Face Recognition. In this proposed method, a face recognition system for personal identification and verification using Principal Component Analysis with different distance classifiers is proposed. These classifiers are: the City-Block Distance Classifier, the Euclidian distance classifier, the Squared Euclidian Distance Classifier, and the Squared Chebyshev distance Classifier. The Euclidian Distance Classifier produces a recognition rate higher than the City-Block Distance Classifier, which gives a recognition rate higher than the Squared Chebyshev Distance Classifier. In addition, the Euclidian Distance Classifier gives a recognition rate similar to the squared Euclidian Distance Classifier.

The state-of-the-art in human face recognition is the subspace methods originated by the Principal Component Analysis (PCA), the Eigen faces of the facial images in [55]. Recently, a technique called Two-Dimensional PCA (2DPCA) was proposed for human face representation and recognition. It was developed for image feature extraction based on 2D matrices as opposed to the standard PCA, which is based on 1D vectors. In this note, that show that 2DPCA is equivalent to a special case of an existing feature extraction method, block-based PCA, which has been used for face recognition in a number of systems.

The contribution of multi-resolution analysis to the face recognition performance is examined in [56]. They refer to the paradigm that in classification tasks, the use of multiple observations and their judicious fusion of the data, feature or decision level improves the correct decision performance. In the proposed method, prior to the subspace projection operation like principal or independent component analysis, they employ multi-resolution analysis to decompose the image into its sub bands. The classification performance is improved by fusing the information coming from the sub bands that attain individually high correct recognition rates. The proposed algorithm is tested on face images that differ in expression or illumination separately, obtained from CMU PIE, FERET and Yale databases. Significant performance gains are attained, especially against illumination perturbations.

A novel subspace method called diagonal principal component analysis (Dia PCA) is proposed for face recognition, which is presented in [57]. In contrast to standard PCA, Dia PCA directly seeks the optimal projective vectors from diagonal face images without image-to-vector transformation. While in contrast to 2DPCA, Dia PCA reserves the correlations between variations of rows and those of columns of images. Experiments show that Dia PCA is much more accurate than both PCA and 2DPCA. Furthermore, it is shown that the accuracy can be further improved by combining Dia PCA with 2DPCA.

As opposed to PCA, 2DPCA is based on 2D image matrices rather than 1Dvectors so the image matrix does not need to be transformed into a vector prior to feature extraction in [58]. Instead, an image covariance matrix is constructed directly using the original image matrices and its eigenvectors are derived for image feature extraction. To test 2DPCA and evaluate its performance, a series of experiments were performed on three face image databases: ORL, AR, and Yale face databases. The recognition rate across all trials was higher using 2DPCA than PCA. The experimental results also indicated that the extraction of image features is computationally more efficient using 2DPCA than PCA.

The face recognition problem is difficult by the great change in facial expression, head rotation and tilt, lighting intensity and angle, aging, partial occlusion in [59]. The Eigen faces algorithm has long been a mainstay in the field of face recognition and the face space has high dimension. The principal components of the face space are used for face recognition to reduce dimensionality. In this paper, the technique PCA is applied to find the face recognition accuracy rate and Kernel PCA is described.

Face recognition has become a major field of interest. Face recognition algorithms are used in a wide range of applications viz., security control, crime investigation, and entrance control in buildings, access control of automatic teller machines, passport verification, identifying the faces in a given database in [60]. Face recognition techniques by considering different test samples. The experimentation involved the use of Eigen faces and PCA another method based on Cross-Correlation in spectral domain has been implemented and tested. The recognition rate of 90% was achieved for the above-mentioned face recognition techniques.

Face recognition has received substantial attention from researchers in biometrics, pattern recognition field and computer vision communities in [62]. In this paper, a face recognition system for personal identification and verification using Principal Component Analysis (PCA) with Back Propagation Neural Networks (BPNN) is proposed. This system consists of three basic steps which are automatically detected human face image using BPNN, the various facial feature extraction, and face recognition is performed based on Principal Component Analysis (PCA) with BPNN. The dimensionality of face image is reduced by the PCA and the recognition is done by the BPNN for efficient and robust face recognition. In this proposed method, Focuses on the face database with different sources of variations, especially Pose, Expression, Accessories, Lighting and backgrounds would be used to advance the state-of-the-art face recognition technologies aiming at practical applications

A lot of work has been done, extensively on the most of the details related to face recognition in [63]. This idea of face recognition using PCA is one of them. In this proposed method, the PCA features for Feature extraction are used and matching is done in the face under consideration with the test image using Eigen face coefficients. The crux of the work lies in optimizing Euclidean distance and paving the way to test the same algorithm using Matlab which is an efficient tool having powerful user interface along with simplicity in representing complex images.

Wavelet Packet Decomposition (WPD) based modification on the classical PCA based face recognition method in [64]. The proposed modification 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. The proposed method was tested with a database containing photographs of 423 persons and achieved 82–89% first one recognition rate. These results are close to that achieved by the classical PCA-based method (83–90%).

Face recognition is one of biometric methods, to identify given face image using the main features of a face in [65]. In this paper, a neural based algorithm is presented, to detect frontal views of faces. The dimensionality of face image is reduced by the Principal Component Analysis (PCA) and the recognition is done by the Feed forward Neural Network (FFNN). Here 50 face images from the database are taken and some performance metrics like Acceptance ratio and Execution time are calculated. Neural based Face recognition is robust and has better performance of more than 90 % acceptance ratio.

The PCA has been extensively employed for face recognition algorithms. It not only reduces the dimensionality of the image, but also retains some of the variations in the image data in [66]. The system functions by projecting the face image onto a feature space that spans the significant variations among known face images. The significant features are known as “Eigen faces”, because they are the eigenvectors (Principal Component) of the set offices, they do not necessarily correspond to the features such as eyes, ears, and noses. The projection operation characterizes an individual face by a weighted sum of the Eigen face’s features and so to recognize a particular face it is necessary only to compare these weights to those individuals.

An appearance-based face recognition method called the Laplacian face approach. By using locality-preserving projections (LPP), the face images are mapped into a face subspace for analysis in [67]. Different from principal component analysis (PCA) and linear discriminant analysis (LDA) which effectively see only the Euclidean strsucture of face space, LPP finds an embedding that preserves local information, and obtains a face subspace that best detects the essential face manifold structure. The Laplacian faces are the optimal linear approximations to the Eigen functions of the Laplace Beltrami operator on the face manifold. Theoretical analysis shows that PCA, LDA, and LPP can be obtained from different graph models. Experimental results suggest that the proposed Laplacian face approach provides a better representation and achieves lower error rates in face recognition.

These algorithms can be classified into appearance-based and model-based schemes. PCA is a typical linear appearance-algorithm, and Elastic Bunch Graph Matching (EBGM) is a two-dimensional model-based approach in [68]. In many applications of Face recognition, the best possible accuracy is required. In such circumstances, existing efficient algorithms do not guarantee good accuracy for the approximations they produce. They propose an efficient algorithm that recognizes novel faces by first localizing a set of landmark features, Approximates the landmark features, and then measuring similarity between these features. For the approach, they used a feature-based algorithm called as EBGM.

An efficient face recognition system based on sub-window extraction algorithm and recognition based on PCA and a Back propagation algorithm is proposed in [69]. Proposed method works in two phases: Extraction phase and Recognition phase. In the extraction phase, face images are captured from different sources and then enhanced using filtering, clipping and histogram equalization. Enhanced images are converted into edge images using a so be operator and then converted into binary images. Finally sub windows from extracted using proposed sub windows extraction algorithm and extract different features (mouth, eyes, nose etc.) from these sub windows. In the recognition phase, back propagation algorithm (BPA) and PCA algorithm is used.

In two-dimensional PCA is used for image representation and recognition in [70]. Compared to1D PCA, 2DPCA is based on 2D image matrices rather than 1D vectors so the image matrix does not need to be transformed into a vector prior to feature extraction. Instead, an image covariance matrix is constructed directly using the original image matrices and its eigenvectors are derived for image feature extraction. The recognition rate across all trials was higher using 2DPCA than PCA. The experimental results show that this approach of extraction of image features is computationally more efficient using 2DPCA than PCA. It is also observed from the results that the recognition rate is high.

III. Performance Review

Face recognition has a variety of potential applications in multi-modal interface, commerce and law enforcement, such as mug shots database matching, identity authentication, access control, information security, and surveillance. Each Face recognition method has categorized based on techniques that they are used in the Face Alignment.

Table I: Face recognition based on active appearance model

Active Appearance Model	Name of the Database	Accuracy (in %)
Sung Joo Lee et al. [22]	BERC	95
Ralph Gross et al. [26]	FERET	95
P. A. Tresadern et al. [29]	XM2VTS	80
Zahid Riaz et al. [31]	(CKFE-DB)	91.17
Kun Peng et al. [33]	IMM face database	NA
D. M Gavrila et al. [34]	FERET	92.5%

As can be seen from table I, Iain Matthews et al have utilized the concepts of Morph able Models and Active Blobs models of a certain visual phenomenon and got a better improvement AAM fitting performance. Sung Joe Lee et al. have to find a suitable facial appearance modeling method for AAMs and experimentally get 95% testing face images fitting performance based AAMs. Gianfranco Doretto et al. have proposed joint variation of shape and appearance of portions of an image sequence. Jeanie Zhu et al. have presented non-rigid shape recovery in real-time augmented reality applications of using an AAM algorithm and get shapes directly from a texture that improve the accuracy of AAM searching. Xinbo Gao et al. has proposed an efficient gradient-based model fitting method with the combination of AAM and they get results improvement in AAM are analyzed. Ralph Gross et al. have proposed a technique, it is empirically compared Generic and Person Specific AAM and they evaluated 95% improvement on a combined model construction and fitting task. Ralph Gross et al. have analyzed efficient approximation to the robust normalization algorithm, which can run in real-time at approximately 50 frames-per-second, and they successfully get face tracking on a number of image sequences containing varying degrees and types of occasions. Ioana Bacivarov et al. have proposed AAM is developed to track and detect eye blinking and they get successfully to robust eye tracking under controlled environment. P. A. Tresadern et al. have proposed the technique of the AAM that is able to track a face on a mobile device in real-time and they got 80% mobile device provide high accuracy. Emanuele Zappaa et al. have proposed new hybrid facial recognition AAM algorithm code that extracts from each of them 58 homologous points and they get results in preliminary tests on a limited database showed a false rejection rate identically equal to zero and a false acceptance rate of about 3%. Zahid Riaz et al. have described a novel idea of face recognition across facial expression variations using a model-based approach and they get the recognition rate up to 91.17% using decision tree as classifier in the presence of six different facial expressions. L. Teijeiro-Mosquera et al. have proposed fully automatic system for pose robust face recognition and they get multi-resolution performance but is sensibly faster. Kun Peng et al. have applied model-based methods by using Active Appearance Models to face verification and improve the system's verification capability with the IMM face database. D.M Gavrila et al. have proposed AAM uses PCA based linear subspaces to model the 2D shapes, textures, and get the recognition rate of constrained AAM is 92.5%, and that of Eigen faces is 91.0%. Rasmus Larsen have applied Statistical region-based registration methods such as the AAM are used for establishing dense correspondences in images and provides better segmentation accuracy than the full standard AAM model.

Table II: Face Recognition Based On Active Shape Model

Active Shape Model	Name of the Database	Accuracy (in %)
Zhonglong Zheng et al. [36]	SJTU	25
Federico M. Sukno et al. [37]	XM2VTS	95
Stephen Milborrow et al. [38]	XM2VTS	95.7
Xiaozheng Zhang et al. [39]	CMU-PIE	92.1
Pedro Martins et al. [40]	IMM & XM2VTS	56.7 &75.4
Behaine et al. [41]	Essex Face Database	95.33
Ping Yan et al. [42]	XM2VTS	97.8
P. Jia et al. [43]	IMM and XM2VTS	94.59 and 85.89
Daehee Kim et al. [44]	Normal	93.8
Sanqiang Zhao et al. [45]	PDM	39.9
Shuicheng Yana et al. [47]	AR	98
Min.Wang et al. [50]	IMM and ORL	95

As can be seen from table II, Zhonglong Zheng et al. have proposed a scheme of ASM algorithms for facial feature extraction and they got a 25% improvement of performance both in localization accuracy and in computational speed. Federico M. Sukno et al. have presented a new segmentation method to solve some limitations of its predecessor, the OF-ASM approach and they save up to 50 % computational time while degrading accuracy by 95%. Stephen Milborrow et al. have presented modifications to the AAM, which make it competitive with more sophisticated methods of locating features in frontal views of upright faces with 95.7 % accuracy. Xiaozheng Zhang et al. have provides a critical survey of researches on image-based face recognition across pose and they find out best 92.1% accuracy in face recognition. Pedro Martins et al. have proposed Point Distribution Model face model and a set of discriminant local detectors with ASM and they get 56.7 &75.4 % results of multiple sets IMM &XM2VTS database. Behaine C.A.R. et al. have proposed an adaptive shape matching ASM technique for Biometric features in face recognition systems and they enhanced the performance up to 95.33% with Essex Face Database in the final face classification results. Ping Yan et al. has presented a complete system for ear biometrics, including automated segmentation and they achieved rank-one recognition rate of 97.8 % for an identical scenario. P. Jia et al. have presented identification algorithm using Mahalanobis distance login subsystem with IMM and XM2VTS dataset and they get 94.59 and 85.89% results. Daehee Kim et al. have presented Model-based object tracking algorithms enable robust tracking with partial occlusions or dynamic illumination and they achieved robustly extract 93.8% accuracy. Sanqiang Zhao et al. have proposed ASM searching method combined with a simplified Elastic Bunch Graph Matching (EBGM) algorithm and they provide 39.9 % improvement. Mohammad H. Mahoor et al. have proposed improved ASM for facial feature extraction and they get an improved version of the ASM is accurate. Shuicheng Yana et al. have proposed a texture-constrained active shape model for face shape localization and they achieved 98% accuracy. Kwok-Wai Wan et al. have proposed modified active shape model is proposed to improve the performance of the original active shape model and they get great improvement on localization accuracy and processing time than that of the original ASM. D. Kim et al. have proposed robust gait recognition algorithm for human identification and get largest gait benchmarking data set with 122 objects with different realistic parameters including viewpoint, shoe, surface, carrying condition and time. Min. Wang et al. have proposed modified active shape model to improve the performance of the original active shape model and they are improved up to 95% accuracy.

Table. III: Face recognition based on principal component analysis

Principal Component Analysis	Type of Database	Accuracy (in %)
F. Tsalakanidou et al. [51]	XM2VTS	98.75
Rajkiran Gottumukkal et al. [52]	UMIST and Yale	95
Seong G. Kong et al. [53]	FERET	54.7
Liwei Wang et al. [55]	FERET	92.1
Hazim Kemal Ekenel et al. [56]	CMU PIE	91.55
Daoqiang Zhang et al. [57]	FERET	91.5
Taranpreet Singh Ruprah et al. [60]	LFI	98.51

Srinivasulu Asadi et al. [61]	Normal database	90
Vytautas Perlibakas et al. [64]	ORL, Essex-Grimace	83–90

As can be seen from table III, F. Tsalakanidou et al. have presented face recognition technique based on depth and color information and they achieved a recognition rate of 98.75%. Rajkiran Gottumukkal et al. have proposed face recognition algorithm based on the modular PCA approach and they get 95% recognition results using UMIST and Yale database. Seong G. Kong et al. have proposed face recognition techniques based on 2D images in the visual and infrared (IR) spectra and they improve the overall performance of face recognition up to 92.1 %. Hussein Rady et al. have proposed a face recognition system for personal identification and verification using PCA and they get PCA give 91.55% results with CMU PIE. Liwei Wang et al. have proposed Two-Dimensional PCAfor human face representation and recognition and they achieves higher accuracy than the typical rectangle block based PCA on the FERETFB probe. Hazim Kemal Ekenel et al. have proposed multi-resolution analysis to the face recognition performance with PCA and they get classification performance improved that attains individually high correct recognition rates. Daoqiang Zhang et al. have find the face recognition accuracy rate and Kernel PCA and they get recognition performances reached 91.5% accuracy successfully in aligned face image. Kiran Jain et al. have proposed Eigen faces algorithm has some shortcomings due to the use of image pixel gray values and gets satisfactory recognition performances could be reached by successfully aligned face image. Taranpreet Singh Ruprah et al. have proposed face recognition method using PCA with neural network back error propagation learning algorithm and they get 98.51% accuracy. Srinivasulu Asadi et al. have presented face recognition techniques by considering the use of Eigen faces and PCA and they get a Recognition rate of 90% for face recognition techniques. Mohammod Abul Kashem et al. have presented BPNN technique combined with PCA and which is given fast, reasonably simple, and accurate in constrained environments such as an office or a household. Parvinder S. Sandhu et al. have proposed PCA features for Feature extraction and they get very practical and powerful algorithm for solving a completely new class of problems. Vytautas Perlibakas et al. have proposed Wavelet Packet Decomposition (WPD)-based modification of the classical PCA-based face recognition method and that achieved by the classical PCA-based method (83-90%). M.S.R.S. Prasad et al. have proposed Face recognition method with FFNN technique combined with PCA, evaluate Face recognition robust, and has better performance of more than 90% acceptance ratio. Xiaofei He et al. have proposed an appearance-based face recognition method called the Laplacian face approach and they provide better representation and achieve lower error rates in face recognition. A. Gunjan Dashore et al. have proposed an efficient method for face recognition using PCA and they get 92% accuracy. Manish Gupta et al. have proposed an efficient face recognition system based on sub-window extraction algorithm and carried out using IIIM_Gwalior database, IIT_Kanpur database and Face_94 database. K Shilpa et al. have proposed 2DPCA method was used for face recognition and they get a clear image as the numbers of Principal Component Vectors.

Table. IV: Face recognition based on Feret Database

References	Type of Database	Accuracy (in %)
Sung Joo Lee et al. [22]	BERC	95
Ralph Gross et al. [26]	FERET	95
D.M Gavrila et al. [34]	FERET	92.5%
Seong G. Kong et al. [53]	FERET	54.7
Liwei Wang et al. [55]	FERET	92.1
Daoqiang Zhang et al. [57]	FERET	91.5

Table. V: Face recognition based on XM2VTS Database

References	Type of Database	Accuracy (in %)
P. A. Tresadern et al. [29]	XM2VTS	80
Federico M. Sukno et al. [37]	XM2VTS	95
Stephen Milborrow et al. [38]	XM2VTS	95.7
Pedro Martins et al. [40]	XM2VTS	75.4
Ping Yan et al. [42]	XM2VTS	97.8
P. Jia et al. [43]	XM2VTS	85.89
F. Tsalakanidou et al. [51]	XM2VTS	98.75

Table. VI: Face recognition based on IMM And ORL Database

References	Type of Database	Accuracy (in %)
Kun Peng et al. [33]	IMM face database	NA
Pedro Martins et al. [40]	IMM	56.7
P. Jia et al. [43]	IMM	94.59
Min.Wang et al. [50]	IMM	95
Min.Wang et al. [50]	ORL	95
Vytautas Perlibakas et al. [64]	ORL	83

IV. Directions for the Future Research

In our review work, Face Recognition process is evaluated by using face alignment and PCA techniques. Here all the proposed methods are working efficiently, among this the PCA based face recognition performance in the real time much better than other two face alignment techniques. As a result, this review paper will be supportive for the researchers to improve the concentration on the AAM and ASM based face alignments techniques in real time database. We believe that in future various works will raise using our review work.

V. Conclusion

In this paper, we have performed an extensive survey about face alignment AAM, ASM and PCA techniques used in face recognition. While all the proposed methods are impartially fairly accurate to our goal of the face recognition technique, we need to further perfect those approaches with different database using techniques that are more efficient. Here the researches categorized face recognition process based on face alignment and PCA techniques that are exploited in a different database and give better advantages are presented. From this review, the researchers can able to know about face alignment and PCA techniques existing in Face recognition.

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